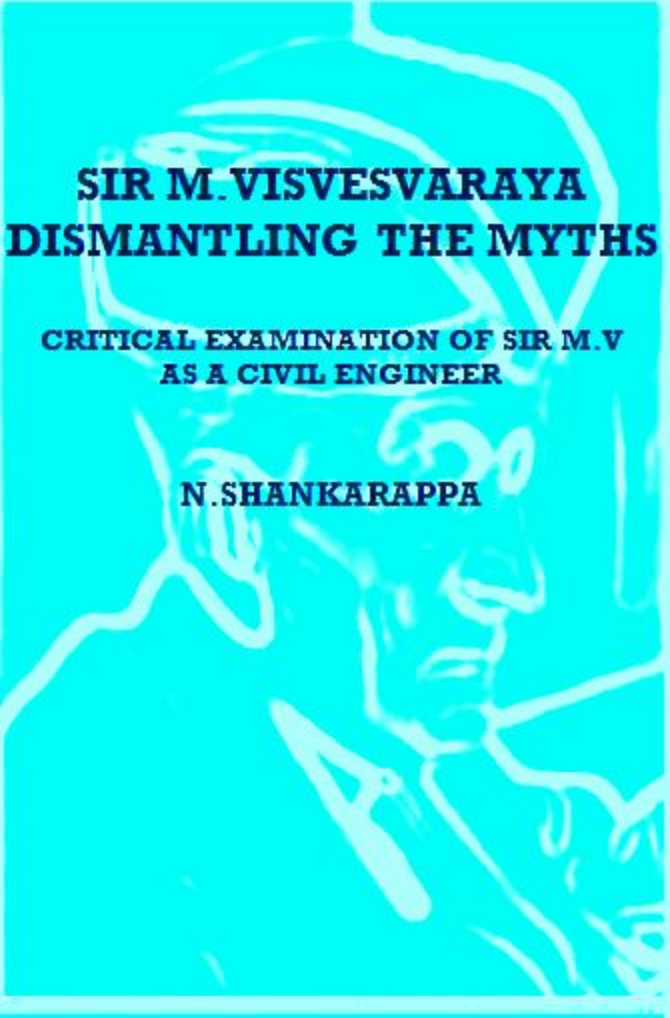
SIR M. VISVESVARAYA
DISMANTLING THE MYTHS

CRITICAL EXAMINATION OF SIR M.V AS A CIVIL ENGINEER

N.SHANKARAPPA



SIR M.VISVESVARAYA
DISMANTLING THE MYTHS

CRITICAL EXAMINATION OF SIR M.V AS A CIVIL ENGINEER

N.SHANKARAPPA

SIR M.VISVESVARAYA DISMANTLING THE MYTHS : CRITICAL EXAMINATION OF SIR M.V AS A CIVIL ENGINEER – written by N.Shankarappa Toranagallu , # 139 , 2'C' Cross , 5th Block , Nagarabavi 2nd Stage-Bengaluru-560072 Karnataka-India

Published by Kavyava Kala Prakashana as E-Book.

First Edition : E-Book
Pages : 215
Price : Rs. 100
Rights : Author

Kavya Kala Prakashana
No. 1273 , 7th Cross , Chandra Layout
Vijayanagara- Bengaluru-560040
Ph : 9964124831, 9035228290

CONTENTS

TO BEGIN WITH

1. SURROUNDED BY MYTHS

2. ENGINEERING OF THE DAY

History Of Dam Design

Tale Of Tails

3. BHAGYA SHILPI : PROFESSIONAL LIFE

3.1 Background

3.2 Block Irrigation Ssystem

3.3 Automatic Gates

3.3.1 Original Concept And Design

3.4 Canal Regulator

3.5 In Design Of Dams

3.5.1 Osman Sagar And Himayat Sagar Dams

3.5.2 Princely Mysore And Irrigation Projects

3.5.3 Marikanive Project

3.5.4 Kannambadi Dam (KRS-Krishnaraja Sagara Dam)

3.6 Kaveri Dispute

3.7 Bhadravati Iron Works (BIW)

3.8 Investigation Of The Bombay Back Bay Reclamation Scam

3.9 Orissa Flood And Mitigation

3.10 Tungabhadra Dam Construction-Technical Committee

4.0 OTHER ASPECTS

4.1 Administration

4.2 Limitations Of Responsibility / Expertancy

4.3 Foreign Tours

4.4 Economic Concepts

4.5 Time Consciousness

4.6 Language

4.7 Merit & Efficinecy

5.0 MYTHS : BIRTH & GROWTH

6.0 APPENDIX

6.1 Engineers Day

6.2 Kallanai

6.3 Nawab Ali Nawab Jung Bahaddur

6.4 India-Egypt-Aswan Project

6.5 Failure Of Panshet & Khadakawasla Dams

6.6 Tippu Sultan & Kannambadi

6.7 Fabricating Myths and Perpetuating Legends : A Case Study

BIBLIOGRAPHY

TO BEGIN WITH

September 15 , the birth day of Bharata Ratna Sir M.Visvesvaraya is declared as 'Engineers Day' . On this day Engineers associations including government departments arrange fuctions to commemorate the legendary personality. Along with technical sessions , discussions , presentation of a few papers also follow. Every time on this day the great engineering capabilities , duty consciousness , forward thinking , progressive outlook of Sir M. Visvesvaraya are sung in great devotion. In general Visvesvaraya is remembered as the pioneer and great engineer who introduced Block System of Irrigation , the inventor of automatic flood control gates, the designer and executioner of Kannambadi (KRS) dam , the original conceiver and realizer of Bhadravati Iron and Steel factory and the Diwan of princely Mysore state who toiled for its all around development. The appreciation and respect towards these achievements are carried forward as traditional legends and not on technical study and critical outlook. This in an extended form has created the myth of 'Visvesvaraya's Brain' among common folk.

Hundreds of articles , a few dozens of books are written on life of Visvesvaraya. All these articles, books repeat the contents of Sir M.V's own book 'Memoirs of My Working Life' in various ways. Nowhere you can find details of the technical designs , prepared reports , methodology of executed projects of Sir M.V in a comprehensive manner. There is great appreciation of Sir M.V as designer of Kannambadi Dam (Krishna Raja Sagara dam), but none has critically studied the designs as engineering demands. Therefore in this book critical technical review has been attempted on the engineering aspects of Sir M.V's achievements. The Chapter ' State Of Engineering' does not directly connected with Sir M.V but it helps to understand the state of engineering prevalent during those days and helps to evaluate the achievements of Sir M.V.

Devotion to master (Guru bhakti) or fear (Guru bhaya) , belief , Blind majority does not have any place in science and engineering. But in case of Sir M.V all these have been combined to deify him. Science and technology demand to separate the personal life from his technical achievements and considers only objectivity . Therefore the eulogy such as 'Sir M.V was great Engineer' shall only be decided on critical technical evaluation and not on sentimental factors. With this back ground in this book effort has been made to know what is the real position of Sir M.V as an engineer , was he really great or mythicized. For this purpose the Civil Engineering knowledge prevalent during the period of 1880-1930 is only considered. Even though the 'loose' literature on Sir M.V is available in abundance , sufficient technical material was not available to me. Therefore using the available material and application of civil Engineering knowledge and judgment I have come to some conclusions. If these conclusions does not match with any hidden/unknown technical sources of Sir M.V, then I will ready to change them accordingly. Civil Engineering Calculations Involved in this book are complicated. To ease the reader from technical jargon I have tried to present technical matters in form of pictures and diagrams. Some old drawings which are not legible are redrawn and may slightly vary with original drawings.

Sir M.V's name was officially Visvesvaraya. But in Karnataka he is called 'Vishveshvaraiah (Vishveshwarayya). It is not clear whether his name was Visvesa Raya as Rama Raya , Krishna Raya. Popularly he is known as Sir M.V. Hence throughout this book he is called 'Sir M.V or M.V

There was dilemma in mind whether to write this book in English or Kannada. Ultimately a question aroused in my mind that why all technical and erudite books shall be restricted to English , why not in mother tongues ? If required this book could be translated to English in future days. Therefore the original book was written in Kannada. This book is full of discussions related to Civil

Engineering. It is difficult for others especially non-technical people to understand the points. Book may seem to be tough but this is not because of the language used but for the subject handled. Book of this nature written in any language will pose same problems . Therefore the book is written in such a way that the people without technical/civil engineering back ground can also read and enjoy the arguments put forward. Non-technical persons who have read this book originally in Kannada has contacted and informed me that even though they did not understand the book completely , in broad way they understood the thesis .

Each language has its own unique features. Kannada and English are no exceptionals for this. During translations at many instances I felt that it is very difficult to bring the expressions in Kannada to English in same spirit and understanding. It was also clear to me that english is a global language on scale of reach rather than its strengths. I request Kannadigas to read this book in original - in Kannada- to have the taste of technical matters written in an Indian language.

Keeping in mind of pan India and outside readers additional topics under heading (a) Failure Of Panshet & Khadakawasla Dams (b) Tippu Sultan & Kannambadi (c) Fabricating Myths and Perpetuating Legends : A Case Study and (4) some technical details which are not in Kannada version are added.

The subjects such as social attitude, the opposition to reservations , personal life , the contact with influential persons , economic thinking of Sir M.V and the socio-political , cast issues that played major role in appointing Sir M.V as chief engineer and Diwan , the foreign tours made along with business tycoons are not in the scope of this book. The experts in these desciplines can throw light on these aspects. As there is mountain of literature praising M.V's disciplined life , duty consciousness , intellectual superiority etc., nothing is there for me to write. I hope that after reading this books one feels that there is need to critically evaluate Sir M.V as an engineer.

Some sources inform that a few days before death Sir M.V burnt his records. Sir M.V is not the first person to do so. Naval S. Tata made will that after his death all his records shall be burnt. After writing 'Jemshetji Nassaravanji Tata : A Chronicle Of His Life' author F.H Haris destroyed all the records connected to J.N Tata. Many times even though the records of famous people remain intact they will be in the locked up secret boxes of their descendants and will not be accessible to researchers. There is a fear that if these records are made available for study then their actions , works come under critical examination and scrutiny which in turn may dim their glory.

At Muddenahalli , the birth place of Sir M.V , Museum has been built in his memory. Only some items which supports his achievements are kept for exhibition. A few books- 4 to 6 in number- which he read , and used are kept in a cupboard. The technical notes , records made by him are not kept. For curious mind which wants to know the nature of technical notes he made during his foreign trips there is no solace. After receiving 'Bharata Ratna' Sir M,V belongs to the nation and not to his family. Therefore all his non personal records must be made available for interested public at certain fixed prices. Then only it is possible to understand Sir M.V ; otherwise legends and myths prevail.

I have attempted to trace how through incidents , anecdotes , stories and myths Sir M.V was glorified and deified. When real facts blur, legends and myths replace them. Through these myths "Great sages' emerge –hagiographies will be written. Objective study is only way to eliminate this blur and myths.

I thank Sonadalagere Lakshmipati who published all my kannada books including this in kannada for publishing in English Version also.

This book is dedicated to Civil Engineering community.

Welcome for discussion and responses.

Shankarappa.toranagallu@gmail.com

N.Shankarappa Toranagallu
B.E (Civil); M.E (Strcutures)
132, 2 'C' Cross , 5thn Block , Nagarabavi 2nd Stage,
Bengaluru-560072, Ph: 8197236971

1. SURROUNDED BY MYTHS

"The Great defect in our past , in fact India's past has been the tendency to exaggerate and the inability to write the correct history. Facts were mixed with mythology and religion. If there was a good king , he was described as the greatest of the kings ; comparable only to the gods; just as many a pious priest who worshiped at a shrine has after his death obtained a shrine for himself and eventually supplanted the original deity itself" (7-364)

- Sir M.V , (7 August 1916 , Speech at Mythic Society 6th Annual Meeting)

A few decades back high school students in Karnataka studied non-Detailed text titled 'Bhagya Shilpi'. While teaching this , teachers mesmorised students by narrating intellectual superiority of a genious called M.V along with his time and duty consciousness , industriousness, non-comprising nature at perfectness of work and other such great qualities. Due to lack of life experiences such explanations created perception of Himalayan personality in minds of students. Among all the stories told about 'intelligence' of Sir M.V remained intact. A few such everlasting impressions are recorded below. [1]

[1] The tradition of honouring those who served British empire in India with dedication by awarding titles GCIE (Knight Grand Commander Of the Indian Empire) and KCIE (Knight Commander of Indian Empire) was introduced from 31/12/1877. Those who honoured with KCIE were using prefix SIR before their names. As rememberence to the birth day of Henry-V , KCIE honours were announced on 3/6/1915 which included the name of M.V who was Diwan of Mysore state along with others. The kings of bigger states got GCIE almost as a rule. Those who were honoured by these titles were supporting the Britisher empire in India directly or indirectly.

Between 1895-1900 British government conformed KCIE honours liberally to the Indian and Egyptian Civil engineers. Civil engineers through their irrigation works were contributing to the financial development of British government was the reason behind this,

The first among them was that Sir M.V was very,very intelligent man . British were not only spell bound but surrendered and sat knee bent in front of his intellectual capacity. British engineers were incapable of building KRS dam ; Sir M.V took that challenege and personaly involved and built the great dam. By seeing this great achievemet British were speechless.

The second myth regarding Sir M.V was far curious than others. Astonished by the intelligence of Sir M.V western scientists – Britain , Germany , Japan etc., - wanted to study his brain . Japanese were ready to pay two crore rupees for that.

The third and great myth was that Sir M.V has built one great dam in Sukkur , Pakistan. He has designed the dam such that a part of it resembles Indian map. By seeing this British and Pakistani's were angry and wanted to remove that part. Afterwards they came to know that if they remove that the dam will collapse and hence they kept quiet.

Not the last but the other story was that once in Europe while travelling in a train Sir M.V pulled the chain and stopped it. Authorities demanded why he has stopped the train. Then Sir M.V. showed a bridge 150-200 M away and said that the rail on that bridge is damaged. If train moves over the bridge there will be an accident and he came to know that by variation in sound as the train moved over the rails.

A few years back one 'professor' remembered in a paper article that Sir M.V used to sit on a rock near Hebbal Kere (Hebbal tank in Bengaluru) and designed the irrigation canal system for KRS dam. This is one of the latest contribution to myths on Sir M.V from a learned 'professor'. In 2017 one superintending Engineer has written a book to make 'Darshan' of Sir M.V in which he has listed 15 names of Sir M.V for chanting (Nama Smarane) and offered lamp worship (Mangalarati).

There are stories that M.V always used carry two pens and two candles. One for personal and other for government work. He always used to keep his resignation letter ready in his pocket. When he resigned he went to Maharaja in government car and returned in own car. The purpose of such stories is to demark the rigid line between personal and government works. Is it possible for a person serving as chief engineer and diwan of the state to demark the activities as person and government official ? Such questions are pushed aside in the background of devotion and praise. There is much appreciation for the Mysore turban which wore MV always. But the fact is that M.V was not able to fold his turban and he employed a school teacher for that at Rs. 30 a month shyly hides behind sycophancy.

M.V who suffered by multiple marriage debacles at the early young age had erased the demarcation between his personal and official work. It was inevitable to him. The admirers of M.V took one step further and declared that every person in public life shall follow this in order to establish his honesty. They also recognized divine qualities in him and viewed his life as that one emerged from perfectness , glowed and completed with no omissions and commissions. It is the life predetermined and moved as a perfect machine with no human feelings.

Among many myths on M.V , high school students were haunted by particularly one that other countries competed to acquire his brain. The imagination of such a 'Brain' was beyond all the fancy and fantasies of the high school students. Students were thrilled that M.V was far more intelligent than British engineers. But when they joined to study civil engineering in no time they observed one thing. Civil engineering has many branches-building, bridges, roads, dams, irrigation, water supply , sewage treatment , river training , airport building etc., and many theories , formulas and expressions come one after the other. There are Euler, Bernoulli , Reynolds, Hardy Cross, Kane. Müller Breslau , Thomas Young , Robert Hook , Betti, Mohr , Terzhagi – all non Indian names . Where is great M.V – why he is not there , haunts them.

M.V is hailed as great water supply and irrigation engineer. Names of Bernoulli , Euler, Chezhi, Ranguli, Kutta , Strange , Manning , Inglis, Sippoletti , Reynolds appear everywhere but Where is our M.V ? Nowhere in the contemporary civil engineering technical papers and circles M.V name is uttered. But from 1950-60 decades Indian names appear in Civil engineering contributions.

The aim of engineering is to adopt the known natural laws to the utility of mankind. Even though this principle is common for all engineering branches , the way in which it is adopted varies. Civil engineering is different in many aspects from other branches. In other engineering branches the work is done under human controlled environment. But in civil engineering earth , water, wind , fire and space are encountered in natural most existence. This encounter is complicated through which technical , social, economic and moral challenges are thrown. A mechanical engineer can test the new possible feasibilities in controlled environment. Manufacturing , electronic , computer science etc.., also operate under human controlled environment.

A civil engineer however intelligent he/she may be cannot build a building , dam or bridge on his own developed ways and test veracity of his new concepts directly. Therefore in civil engineering the established theories and researches can only be brought into the public use . A car company , a computer company can take back its defective product and rectify them. But the defective building , dam , bridge can neither be rectified easily nor dismantled as both have their own social , economic adversaries. Behind every civil engineering activity there will be extensive calculations, To carry out such calculations technical guidelines are formulated. Civil Engineers recognize them as 'Codes Of Practice'. These practices are active behind all the civil engineering activities in the world. These practices enforce a civil engineer to follow disciplined path before adopting engineering principles to actual work. Any new field of engineering emerges along with its guide lines , codes.

In this back ground question arises that while designing water supply schemes , irrigation projects , dams which guide lines and codes were followed by M.V. Who prepared those guide lines and codes ? The curious questions such as when M.V designed KRS dam who were the engineers in his design team ? Did they adopt all available guidelines and codes while designing the dam arise. But there is no information to quench this curiosity.

Construction of KRS dam brought all India fame to M.V and was raised to deified celebrity status in old Mysore region. While telling about KRS dam. M.V in his 'Memoirs of My Working Life penned that for him who was seen Aswan Dam in Egypt and big dams in Maharashtra during his service years designing of KRS Dam was not much an effort. Thus M.V's professional memories does not give any technical information but flow as fantasy stories. Those who believe in the great intellectual power of MV may be satisfied with these statements but it is not strange that a civil engineer who wants to know the prevailing engineering practices of those days will be disillusioned.

A person in public service represents a position and perform his duties through it. Here the position is important rather than the person. During British rule the name of reservoirs and dams were named after the chief engineers who constructed them. In future years this practice was abandoned. Immediately after independence of India and in future days many big dams were constructed. Immediately after independence the challenging Bhakra dam was constructed. The design and construction was carried out as a team work. There always remains question that is it correct to say that a dam has been built by any single engineer. Construction of dam is always a team effort and not an individual endeavor. The leader of any project will be standing on the shoulders of others. M.V takes the credit for the projects done when he was executive Engineer and do not name the chief engineer but when M.V becomes chief engineer he boasts that the works were done by him and does not give credit to the executive engineer. Nowhere M.V says that the team under my guidance did

it. If so question remains that does the achievements belong to the group of engineers or to an individual ? As an exception M.V has acknowledge two engineers who supported him in mitigating floods of Musi and Easi rivers which endangered Hyderabad city.

Professional biography shall have pitfalls of working life along with success- failures, criticisms- appreciations and sharing of experiences along with identifying the one's limitations. It shall also be a source of inspiration as well as caution. M.V's Memoirs of My Working Life does not have such features. M.V has penned this book to suit his own opinions , fancies and public policies In this biography there is no difference between social work, public work or the technical work of building dams. Barring M.V's own biography his professional life can be known through the project reports submitted by him in Bombay Government. M.V has written his biography at age of 90 by referring his old diaries and lacks much needed details.

'Memoirs of My Working Life' does not provide any insight or inspiration to a practicing engineer and thus it is dry. It does not address important points a practicing engineer wants to know such as when large projects are taken up in public money what are the aspects to be considered in design , how detailed project reports to be prepared , what precautions shall be taken in determining the cost of project , what alternative strategies to be adopted to resolve the critical situations that arise , what type and hierarchy of management is better , how the large projects are handled in developed western countries , what is the collective responsibility of the persons involved , what were the challenges and obstacles faced in construction of KRS dam and how they were overcome , what quantity of fire wood was needed to make surki , what spread of forest area was devastated to obtain fire wood , while taking up large projects in future what major effects to be envisaged etc. After construction of KRS dam , civil engineering field advanced rapidly. M.V does not try to compare the design done for KRS with that of latest concepts. M.V tries to tell engineering stories through his jotted diaries.

Before taking up the construction the project cost of KRS Dam was estimated. The construction progressed for next 20 years. Memories of M.V does not contain such important information such as whether In original project report the cost escalation effects due to unavoidable circumstances were considered or not. M.V was the head of the enquiry committee for Bombay Reclamation scam. During hearing of the pleas M.V observed that between 1912-1919 in span of 7 years cost of materials inflated by 75 % and cost of labor by 100 %. The KRS dam work stretched for 20 years , was there no price escalation ? was it completed within the estimated budget ? Does price variation were not existent for two decades ? All such important points seem to be of no significance for M.V

In this book M.V goes on narrating the projects executed , reports submitted , works done , responsibilities held without any proper back ground in monotonous monologue style. This is like a person signing song composed by himself , praising himself. In views of M.V there are no differences, contrasts between the problems encountered as assistant engineer in laying syphon pipes and construction of KRS Dam. It is evident that regarding Automatic Flood Control Gates and KRS project M.V is hiding many facts and not telling the whole truth. 'Memoirs of My working Life' contains neither complete objective nor correct information nor correct information. The book does not have any references , reports , texts or bibliography . This applies to all from small to large projects. This is the great lacuna of this book.

There are more than 29 and 18 books on M.V in Kannada and English along with hundreds of articles. All this 'literature' without subjecting M.V to minimum critical examination praises as ' worlds famous Engineer'.

Yalanduru(Y).Gopalashastri(G)Krishnamurti (YGK) has written biographies of prominent people who were active in politics/public life before independence. For those books forward has been written or wishes have been conveyed by luminaries like Babu

Rajendra Prasad, Jawaharalal Nehru , S. Radhakrishnan. Y.G Krishnamurti was secretary for M.V and was drawing monthly salary of Rs. 75. Y.G Krishnamurty has written a book titled ' M.Visvesvaraya- A Study' which was published by well known industrialist of Bengaluru B.M. Srinivasaiah. In this book Krishnamurti notes that M.V was not interested to hear his own voice and expected critical views from others. YGK also informs that his acquaintance with M.V is more than any document. Throughout this book YGK subtly goes on glorifying and deifying M.V and nowhere records the dissent voice heard by M.V. He also writes about an ongoing rumor that American Government is trying to purchase the brain of M.V. He also adds that when this rumor reached M.V , he was enjoying that and did not give any clarification to the public in that issue. If we observe this it is very doubtful that M.V ever heard dissenting voices. Therefore the life and achievements of M.V shall be studied carefully from the available sources.

In 1960 , two years early of M.V's centenary celebrations M.S. Tirumala Iyengar , the adviser for Public Works Department of Mysore state , the administrator of Sharavati project and Ex-chief engineer of Hirakud project and A.N Murty Rao the Ex president of Kannada Sahitya Parishat have written articles in jornal YOJANA (4/9/1960- Issue : 17, Volume: 4) published from Delhi . In these articles M.V has been projected as 'Yuga Purusha' 'King' and 'Deity'. Since A.N Murty Rao hails from literary back ground we cannot expect much from him and can allow his figure of speeches. But the article by M.S Tirumala Iyengar , Retired Chief Engineer, Adviser to the government is not diffrerent from that of A.N Murty Rao is most disappointing. Tirumala Iyengar considers every work done by M.V as a miracle. When person like Tirumala Iyengar , technocrat who has to represent objective thinking is presenting M.V as ' Miracle of Engineering' who else can question M.V ?. The tradition of shunning critical examination , technical evaluation and adoring M.V as god thus began. A particular class of people in Karnataka perpetuated these legends and myths as an agenda.

Based on the speech made by M.V at Mythic Society on 7/8/1916 , the life and achievements of M.V have to be seen by detaching him from myths , legends and sycophancy. Therefore putting aside the exclamations such as ‘ Can engineer like M.V will born in this world ? can such genius exist ? we have to critically examine and objectively evaluate the real works and determine the true contributions of M.V to civil engineering field.

Large number of books euloging the intelligence , human values of M.V are written but no study has been made or nothing has been written by evaluating the capabilities , skills of M.V as an engineer. To fill up that lacuna attempt has been made in the following pages.

2. ENGINEERING OF THE DAY

Understanding the prevalent condition of civil engineering of those days help to review the achievements of M.V critically. Therefore in this chapter the developments in irrigation and dam construction engineering in 19th century especially second half of it is considered

Since rain is uncertain in India, from time immemorial the attempts were made to stop the flow of streams , small rivers and store the water for various purposes including irrigation. The skill and some practice based ' technology' was known to build earthen dams of varying heights from 3 to 8 M. In south India thousands of such earthen dams were built. The Indians did not have technical capability to build high stone masonry dams to stop flow of big rivers. Therefore they built earthen/stone dams across big rivers just before the delta plains of the river where the velocity and depth are very low due to spread of the river. By doing so , the depth of flow in the river was raised and water was diverted to irrigation canals on either side of the river.

In 10th century 'Madhava Mantri Katte' was constructed across Kaveri river in Karnataka and at the same time Kallanai was built across the same river by Karikala Chola in Tamilnadu. Vaigai river in Tamilnadu had such low height stone dams. In Tamilnadu there was practice of building 'low dam' like obstacles using stone , timber , earth etc. during summer. When water level in rivers dwindled these structures stored water temporarily. In Karnataka near Kenchana Gudda of Siruguppa Taluk low dams were built in 16th century to divert the flow for irrigation canals. Since ancient times hundreds of irrigation channels were dug on Indus river to divert the flood waters to irrigate the fields.(13) All these water sources were under the administration of local rulers.

As the British who came to India as traders became the rulers their responsibility increased. When India underwent series of famines the water sources dried up and the people were distressed. The

reservoirs have lost their storage capacity due to silting. In 1832 famine hit Bombay province (Maharashtra-North Karnataka-Telangana) and lakhs of people died of starvation. Due to 1848 famine the revenue sources from agriculture dwindled. In black cotton soil it is not possible to till after heavy rains because the tilling blades struck into wet cohesive soil. Therefore the farmers practiced tilling of the lands immediately after a small sprinkling rain and sowed the seeds and waited for next rain. When the expected next rain did not arrive they panicked. (5) The wells usually were empty and insufficient even to cater for drinking. Gradually people started to feel that the new administrators – outsiders, British – are not giving sufficient attention to maintain the water bodies as the local kings and chieftains did and hence the current water crisis had risen. Even some British Engineers were not happy about their own government which did not give sufficient attention to the problem. (5) Edmond Burke condemned the apathy of the government in strong terms and said that these are not your achievements , the people inherited them from their forefathers and they shall not be destroyed to your whims and fancies. British engineer Arthur Cotton and the chief engineer of princely Mysore state Sankey admired the traditional water management of locals. (11). Arthur Cotton was very angry of the attitude of the government towards water management .

British gradually started to realize that to get established in India as rulers they must have plans to face famines which have wide and deep effect on people. Water and irrigation shall be taken seriously and by improving the traditional water bodies and management the confidence of the people shall be won. British had their own way of looking at these issues. They considered everything on commercial terms and took the irrigation projects when interest rates worked in favor over the investment. In Ganga-Yamuna region the interest on investment was attractive but not in Bombay province. The series of famines between 1830-1870 forced them to think in different way. In south India even though the interest rate on the investment made on irrigation projects was very low and unattaractive when compared to the money spent during famines ,

the former was better option. This forced British to store water by building large dams and invest on irrigation projects. They also came to the conclusion that the money can be recovered through taxing of the irrigation water. Thus in south and north India the effect of British administration started to show its effect and possibility of construction of large dams and storage of water started.

Initially British were forced to face the challenge of water storage and management in Kaveri valley in south India. Before entering delta plain near Tanjore Kaveri river splits into two branches Kolladam and Allar (=Kaveri). These two branches merge once again at downstream. Srirangam is the island between these two branches. On the downstream of Srirangam , before these two branches merge a stone dam(Grand Anicut , Kallanai) was built across Allar (=Kaveri) in 10^{th} century to facilitate irrigation. Kallanai was not the dam in modern sense but a low height (3-4 M) stone rubble heap with large base of 12-15M. Due to lack of maintenance for long period Kallanai was silted and its storage capacity was much reduced . In 1804 Capt. Caldwell increased the dam height by 0.69 M and provided vents to facilitate the removal of silt. At the same time it was observed that due to silting in Kaveri river , the water flowed towards Kolladam. The responsibility of finding a solution was put on the shoulders of Arthur Cotton. Even though Arthur Cotton repaired the dam by increasing the height to 5.4 M and base to 20 M , it was not a final solution

By 1825 the silting of Kaveri resulted in flow of much water towards Kolladam jeopardizing the area spread over 200-2500 Sq.Km which was irrigated since 1000 years under Kaveri. There was danger of loss of crop in future years. (11)., As a solution to this Arthur Cotton proposed to build one more dam slightly upstream of Kolladam-Kaveri branching. By doing so the water level rises behind the dam which enables the equal flow into Kollam and Kaveri. Arthur Cotton who was highly influenced by the traditional method of Kallanai construction took up the work and built average 2.0 M high dam on upstream of branching in

1836. This is known as Upper Anicut (Mukkombu). By constructing this dam the water flow in Kolladam branch being reduced affected the traditional irrigated area of delta plain. To overcome this one more dam of 1.8 M height was constructed 112 KM downstream of Upper Anicut. This was called Lower Anicut. The material required for this dam was obtained from the ruined temples of Gangaikonda Cholapuram. (15) . The irrigation area expanded many times under Upper & Lower Anicuts. The irrigated area which was 4.6 Lakh Acres in 1891 was expanded to 11 Lakh Acres in 1899. (11). The success of this project brought great confidence in British in water control and management.

The problems faced in Godavari and Krishna basins were different and much more difficult than Kaveri Valley. During famine of 1832 the distress of people in the Godavri valley region reached peak and disposition and cremation of dead bodies was a challenge. The land in Godavari and Krishna basin was in the hands of large land holding Zamindars which was depended on small tanks and wells . The famine was a bolt from blue to them. British government confiscated the land of tax defaulters but what to do with this land was the toughest question to answer. To find a way to resolve this Montgomery was sent to Godavari basin. He decided to lease the confiscated land to the small farmers. How can small farmers can come forward to cultivate waterless area where land lords themselves failed. As an answer to this British Government decided to initiate and extend the irrigation projects. (11)

During the same time when Arthur Cotton travelled through Rajamahendri of Godavari basin and he immediately observed that unlike Tanjore belt in Kaveri basin there was no development in Godavari delta. He dreamt to transform the Godavari delta into greenery similar to Tanjore plain. He prepared a detailed project report and submitted to the government. By seeing the estimated cost of the project British government shivered. Arthur Cotton in his detailed report has raised these questions himself and did answered them in foot note. He proposed to build dams across Godavari near delta plain , supply the water for irrigation and tax it

through which investment and interest on it can be taken back progressively. The dam proposed by Arthur Cotton was very similar to Grand Anicut comprising of ruble stone construction of low height and wide base.

The proposal got approval in 1847 and the construction was started and completed in 1852. More than ten thousand labors per day were engaged for this work. During construction Arthur Cotton lived on the bank of the river in thatched hut. Two children who were born to him in that hut died there itself in very young age. After completing the barrage at Dhavaleshvaram which is down stream of Rajamahendri , 0.6 M high gates were erected to increase the storage capacity. Before the construction of the barrage the irrigated area was 18000 acres and after construction this was expanded to 640000 Acres. This was great mark of success and Godavari delta became the second heaven after Ganga-Yamuna doab region. Now there stands Arthur Cotton Memorial Museum at Dhavaleshvara (11) [2]

Lt. Bailson who saw Grand Anicut on Kaveri wanted to build such dam across Krishna River near Vijayawada. But his dreams were never realized. In 1847 Captain Wear conducted study and made a report to construct dam across Krishna river. For this opinion of Arthur Cotton were sought. In 1837 itself Arthur Cotton had proposed to build quarter mile wide dam across Krishna at upper reaches. To obtain the construction material he envisaged to blast e 1 lakh pound dynamite at 10 places. He also argued that one more balancing reservoir shall be built on the upper reaches of Krishna river. This was considered as mad childish proposal and was never discussed. But in later days same projects were executed as Tungabhadra and Nagarajuna Sagara Projects by independent India.

[2] In 1960 the barrage was damaged badly due the heavy floods in Godavari and as safety against this concrete barrage was constructed on the upstream of the damaged barrage.

In later days British Government started to rejuvenate the old facilities along with new constructions. Under this scheme Meadous Taylor rehabilitated Bonal tank near Surapura which was built in middle ages. In 1857 one tank was built near Kachakanur. After 1885 much support was given to such projects. In 1886 old irrigation canals which were irrigating nearly 25000 acres of land were repaired.

Even though abundant water was flowing in Ganga-Yamuna region the storage and maintenance was no different from South India. When famine occurred in 1837 and 1840 in North India , in United Provinces (Uttara Pradesh) more than 20 % people died. This forced the government to look at irrigation projects. (16)

Since from ancient times the practice of excavating canals parallel to the banks of the river and divert the flood water for irrigation was in practice. In 1350 Mogul king Firoz Sha Tughalak ,constructed a canal on south bank of the river named Nahar-E-Bahist (River of the Heaven) to transported the water to Hasi-Safida area of Haryana. Short time after his death this canal became inactive. Akbar in 1568 , Shahajahan in 1628 tried to repair this old canal. But at the end of 17^{th} century the canal was nearly dead due to silting. Some efforts were made to reclaim it but failed. British government took this work in 1820 , changed the alignment of the canal wherever required , added 720 KM long main and distributary canals. (11,16). The canal on eastern bank of Yamuna river which was constructed during the rule of Mohammad Shah was silted fully. This canal was also rejuvenated.

Proby Thomas Coutley is considered as the British Engineer with Indian heart. Between 1840-1856 he constructed series of canals in Ganga basin and etched his name in annals of history. In 1840 Proby T. Coutley prepared a report proposing Upper Ganga canal with capacity of 283.75 Cumecs. He was firm that if this quantity of water is conveyed then only the returns on the investment were feasible. After one year the Coutley proposal was revised , the capacity of canal was restricted to 190.52 Cumecs and construction

approval was accorded. For the required engineering of this mega project first engineering college in India –Thomason College Of Civil Engineering (Now , IIT Rourke) was started. Design and construction canal in sandy soil was a challenge. (16). When the canal was completed Coutley was richly experienced and was able to solve all engineering problems.

From 1845 to 1848 Coutley visited Italy to understand the problems and latest advancements in irrigation engineering. In those days Italy was pioneer in it. In 1850 Coutley sent his assistant engineer Richard Baird Smith to Italy for acquiring higher knowledge. In 1852 Baird Smith published ' Italian Irrigation'. By 1848 more than 1280 KM long canals were constructed and more than 7 lakh acres land was brought under irrigation. The supplementary works of this canal were completed by 1854. Coutley planned to plant saplings on either side of the canal at 40' distance , spaced at 100' which have to be watered through holed earthen pots. (11,16). In North India except east and west canals of Yamuna river all other canals were constructed by British. After appointment as monitoring engineer of the Ganga Canal Richard Blair Smith travelled more than 2400 KM to study the projects implemented by Arthur Cotton. He visited most remote places travelling by palanquin for 6 weeks. In 1856 he authored the book ' The Kaveri , Kistna & Godavari'. British engineers Medus Taylor, Proby Coutley, Blaird Smith , Arthur Cotton and such others believed irrigation engineering as their god and religion (11)

The western parts of Bombay province were haunted by cyclic famines. To alleviate this problem in 1868 Col. J.G Fife proposed a project to build a dam across Mutha river which is 20 KM away from Poona. All the barrages built before, across Kaveri , Godavari, Ganga-Yamuna were of maximum height 5.0 M. But the rivers in Bombay provinces were small and seasonal rivers. Without building high dams much water cannot be stored. Therefore Fife wanted to build high dam which was unheard in India. The approval was accorded in 1870 and dam construction was started at Khadakavasala. The dam had outer stone masonry and inner

concrete core with height of 31.42 M from river bed and 39.65 M from founding level. In 1879 Mutha left and right bank canals were completed and 49800 Acre was brought under irrigation. Through this British engineers acquired the knowledge of building high dams. [3]

By 1898 all works were completed and water was let for irrigation. In future decades , to increase the irrigation area proposals were made increase the dam height. After technical deliberations it was decided to build new dam of 51.24 M height downstream of the existing dam. As a result of this Lloyd reservoir came into existence submerging the old Bhatghar Dam. Between 1875 and 1920 , in 45 years span more than 50 projects comprising of tanks , dams , water supply , irrigation were completed.

In 1863 Col. Fife had proposed second project to enhance the irrigation facilities by constructing a dam west of Poona city , across Elavandi river slightly upstream of Nira and Elavandi river confluence and started preliminary works. To study the feasibility of the project a committee was formed in 1868 under the leadership of Whiting. Review of the project continued and in 1871 recommendations were made to construct dam across Elavandi near Bhatghar (Whiting Reservoir). The additional water from this river was to be diverted to Nira. Construction of one more barrage across Nira river near Veer with irrigation canal on left bank and bringing 275000 acres under irrigation were also recomended.

The Periyar Dam built in Kerala took the British engineers to one more higher level. Even though Tansa Dam built to supply water to Bomaby city was completed earlier than Periyar , by engineering considerations Periyar dam was unique. Periyar river receive water from heavy rains in western ghat area and joins the sea near Kochin. The enormous water in this river cannot be utilized due to

[3] The reservoir formed by this dam was named Fife Lake. But after independence this was renamed as Khadakawasla damand reservoir.

forest area. To the east of Periyar river valley Vaigai river runs. From historic times small obstacles were constructed across Vaigai river for purpose of irrigation. While Periyar water was not utilized , Vaigai water was utilized to such an extent that the water did not reach sea. At some places the Periyar and Vaigai basins are separated by narrow ridge. By removing this ridge water from Periyar could be diverted to Vaigai.

In 1798 the Diwan of Ramanad , Arulapillai constituted 12 member committee to study the feasibility of diverting the water from Periyar to Vaigai. Even though the committee reported the feasibility of the project due to economic reasons it was not taken up. In 1807 Madurai collector Parish was interested in the project and while travelling in the forest he was unwell and hence stopped the work and returned. But next year he deputed Caldwell for the study. Caldwell reported the project is not viable due to high costs involved and consequently projected was abandoned. In 1850 Faber tried to build small dam across Periyar and failed. The studies done afterwards clearly indicated that there is no use in building small dams. In 1862 Joseph Gore Ryves blew life into dead Periyar project and in 1867 proposed to build 53 M high earthen dam and prepared the report. In 1877 R.Smith argued for construction of massive earthen bund can be built using Hydraulic Placement Technique. Since no dam of that size was built anywhere in the world and due to lack of experience in that technology Madras Chief Engineer General Walker rejected Smith's report and directed him along with Pennycuick to study the feasibility of constructing stone masonry dam. Previously R.Smith had argued against stone masonry dams due to their huge cost. Either due to the changed situation or after knowing that the large dams were under construction in Bombay province , Smith Changed his mind and came forward to take the responsibility of building the dam. The project was pushed aside due to famine in 1876-77. On 8/5/1882 Pennycuick was ordered to prepare the revised project report. At the end of same year permission was granted to build the dam. The dam at deepest river level is 60 M and on other parts 54 M high.

This dam broke all records of that time in height and magnitude. In September 1887 the actual work started.

Many technical and non-technical challenges stood face to face. The flood water which stood near the dam site up to march hindered the construction activity , the labors suffered from forest fever , the nearest cart path from the site was 11 KM, the land to be irrigated was 32 KM away , nearest railway station was 128 KM away posing challenge to material transport. Attempts were made to replace labor work with machines. While foundation work was started a deep trench of 12 M wide and 3.6 to 5 M deep was encountered unexpectedly. The water seeped through this trench under pressure which made removal of water and construction of foundation a herculean task. The construction of tunnel to divert the water towards Vaigai , the design of tunnel entry , the design , manufacture and erection of control gates were some of the unparalleled challenges which demanded engineering bravery. When the dam was completed in 1895 , the history of Indian dam building reached the new level. Sir John Wolf Barry who was close observer of the project declared that ' The technical ingenuity in designing , the tight control in construction , the dedication of all those workers who achieved this shall be recogniesed but one and all'. [4]

[4] During heavy floods the quantity of water flowed in Periyar river was half of the normal flow of Nayagara river. Therefore the foundations of the dam was washed away a few times. At this stage British government stopped the financial aid to this project. Undaunted Pennycuick started the foundation work for the second time, British government did not provide any financial help for this and hence Pennycuick was depressed for some time. Grace Georgiana Chamiar , wife of Pennycuick who saw this supported her husband to mobilise funds for the initial foundation work by selling her personal ornamants , articles. Pennycuick who was determined to build the dam tried to collect money through his contacts and influence in Madras. Even after this , sufficient money was not mobilized. There are reports that determined Pennycuick and his wife sold their properties in England and ultimately were able to collect 45 lakhs. In future days this money was returned to them. But historian of Kerala M.G.S Narayana contest this and says that there are no records to substantiate this.

In the history of Indian irrigation Punjab and Sindh have their own place and prominence. The Punjab and Sindh provinces which are now in Pakistan were under Bombay presidency until second decade of 20th century. The priority was given to the irrigation projects in western Bombay province (Now, Maharashtra state). Madras and Northern provinces were developed for irrigation but there was no such progress in Punjab and Sindh.

In Punjab & Sindh region , hundreds of irrigation canals were on Indus and other five rivers (Jheelum , Chinab, Ravi , Biyas, Sutlej). Many of these rivers were silted and useless. J.J Fife who was working as superintendent engineer of Bombay province between 1855-1859 connected eastern Nara canal to the Indus river. This canal was in good condition until 1932. Fife was able to identify the shortcomings of flood canals and advocated the water storage and conveyance. Fife prepared a project report to irrigate Sindh by 5 main canals with barrage construction. Bombay government rejected them. Even if Bombay government accepted it was not possible to take up that project without cranes, bull dozers , draglines and special construction vehicles. (these equipment's and vehicles became reality after 40 years from Fife report). French engineers used such equipment's first time in 1869 for Suez canal construction). In Sindh region except flood canals there were no barrages. First time in 1894 , a barrage was built across Nara river (Jumrao Project) , water was stored and supplied for irrigation. After this British constructed huge network of canals (Unada , Dhaamrao , Prachand, etc.,) brought additional area under irrigation.

In 1858 when J.J Fife rose to the post of Chief engineer proposed the construction of 132.65 Cumec (4712 Cusec) capacity canal. After nine years this report was accepted and sent for review by

---

Pennycuick was cricket lover and tried hard to establish the game in India. Pennycuick who was the allrounder was playing on behalf od Bangalore and Madras cricket clubs. He was the secretary of cricket club of Chepauk, Madras.

Capt. Le masuriar. In 1867 the revised report to irrigate 815544 Acres was finalized. In 1871 as a part of three projects (Guddu-sukkur-Kedri) the feasibility study of construction of barrages was taken up. In 1872 when Viceroy Lord North Brook visited Sindh , he cancelled all these projects. A report highlighting the failure of traditional flood water irrigating system in Sindh and its obsolete methods was submitted along with proposal for new ways to upgrade them. Cold response came from the viceroy as he was against any new project in Sindh. In contrast while Sindh flood canals were supplying water for 90-120 days during flood season , the Ganga-Yamuna canals with barrages were supplying the water all along the year. By 1890 the situation deteriorated to such an extent that it was impossible to irrigate through the existing canals. The Fife who proposed stored water irrigation 40 years back who knew their importance wrote a letter in 1890 and urged for permanent irrigation solutions. [5]

In 1903 Irrigation Commission recommended that three projects (Guddu-Sukkuru-kedri) as feasible ones. In 1906 four projects locations (Mirankol , Sukkur, Sehwan, Kedra jaraak sehvaan) which facilitate permanent irrigation facility to Sindh were considered and Sukkur proposal was recommended. In 1913 Dr. Summers Committee which was formed to study the feasibility of barrage construction listed the nature of mass work , the obstacles for come and declared the project is not viable as it could earn only 4.5 % interest annually on invested money. After this it was opinioned that by constructing the canals first and taking up the barrage work afterwards the repayment load could be reduced. In 1913 there was steep deficiency of cotton supply to mills in England. The competing countries such as USA and japan had their own cotton growing areas. Therefore to make themselves independent on cotton supply British government decided to bring Sindh under permanent irrigation schemes.

[5] The origin and pronounciation od 'Sukkur' is not clear. In Sindha locals call this as 'Sakhar'

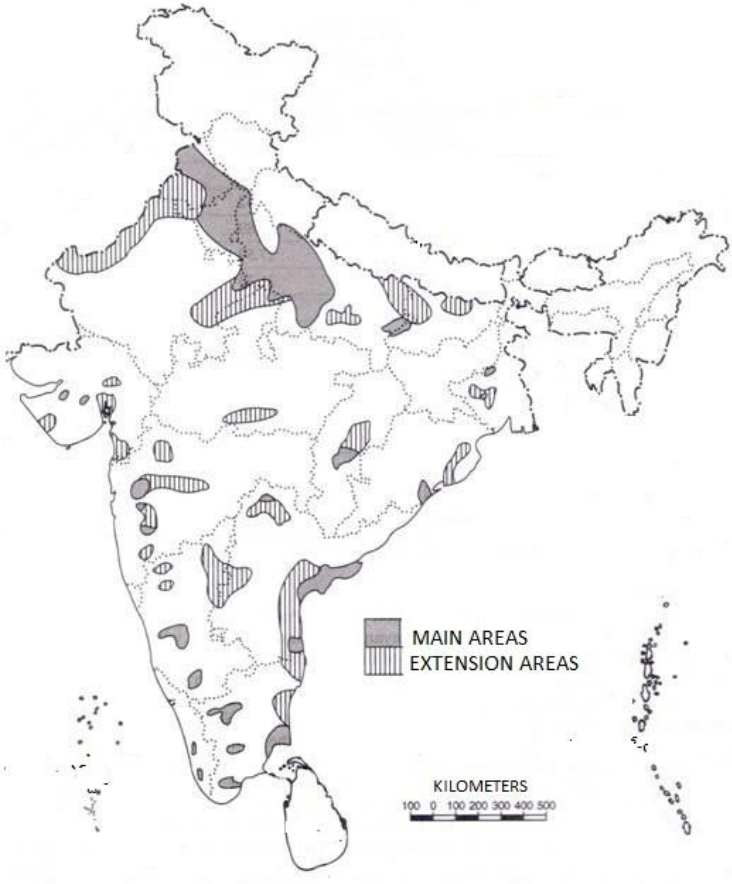
Regarding construction of Sukkur barrage many discussions continued and final approval was occorded on July , 1923. Gulam Mahammad Burgari and Seth Harachanda Roy were in continuous contact and pressurizing the British Government to implement it. Due to many such efforts the construction of barrage was started on 1 July 1923. The local board of Larkana town made a resolution to call the barrage as ' George Lloyd Barrage' in honour of then England prime minister.

Sukkur Barrage was the world's largest project taken up. Thousands of labors were required for the construction work. In 1917 influenza was spread and the 40 % rural population was wiped out and the labor force for agricultural activity was in acute shortage. There was the fear that If rural labors are engaged then there will serious effect on agricultural sector and the scarcity of labors also results in higher wages which ultimately cross the budgetary limits. Therefore engineers were forced to think of alternative ways.

Between 1903-1920 there was revolution in construction machinery and equipment's. While in 1903 Henry Ford company manufactured Model-B cars , Caterpillar company expertised in crawlers and tractors. Le Tarnia company produced scooper, bull dozer , blade , power winch and brought them to construction. Ruston in England developed stable and portable diesel engines. This company in collaboration with Bisparus manufactured clam shells , crane , drilling and blasting rig, pile hammer compressor and multi cylinder diesel engines. For higher power movable steam engines were manufactured. These new machines and equipment's eliminated human and animal role in excavation , transportation , blasting and revolutionsed the construction concept. With these the Sukkur project once which was thought to be impossible to execute through human effort was considered as possible and feasible. The amount invested on these machines, equipment's was nearly 22 % of the cost but when compared to the human labor component it was cheaper.

Before taking up the canal construction the area to be irrigated was divided into blocks of each 320 acres and subdivide to 1 acre. The canals were laid at the periphery of these blocks and conveyed water very efficiently. The water tax was fixed at the beginning and entire area was subdivided into four classes as fertile , semi fertile ,poor and useless. To control leaching and water logging ground water table meters were installed. Before Sukkur barrage the irrigation was under flood canals but afterwards the controlled stored water was available. In 50 years the irrigated area expanded to 3.5 times the original area and population by 6 times. The total cost incurred for Sukkur barrage and canals was approximately 5.6 Crores. Through Sukkur dams the British engineers were famed as the executers of the biggest irrigation project in the world. (17)

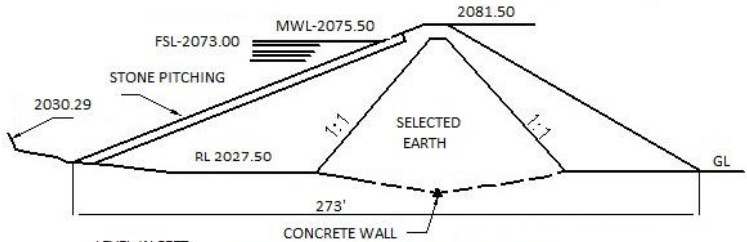
From third decade of 19th century to start of 20th century in span of 70 years British took up various irrigation projects and completed them successfully. In 4th decade Kaveri and Godavari delta area , 5th decade Doab , Ganga valley and Krishna delta , 6th decade Bombay and Bengal (4 canals) , 7th decade Bengal , Bihar (Sona canal) , Bombay province (Mutha , Nira canals) , Ganga plain canals (Ganga lower and Agra canals) , 8th decade Sindh province (sir Hind canal) , 9th decade Chinab canals were completed and revolutionized the Indian irrigation . The irrigated area which was 30-40 lakh hectares before 1830 was expanded to 2 crore Acres by beginning of 20th century. Biritish added 1.5 Crore acre irrigation area beyond the existing area. The canals totaling 70,400 KM were constructed. The investment brought 6-7 % returns per anum. In execution of these projects British engineers built large dams , faced the challenges and succeed in it. By British new era of irrigation started in India.



CANAL IRRIGATION IN INDIA

2.1 History Of Dam Design

In India , especially south since from ancient times there was tradition of building tanks , anicuts to store water. Most of these reservoirs have earthen bunds. It is possible to build such bunds up to a height of 15 M across small rivers and streams. The traditional knowledge for this was accumulated through centuries. This knowledge was purely empirical and did not have any scientific basis. Therefore failure of bunds was common phenomenon. The earthen bunds were suitable for small rivers and up to certain height and was not possible to build across big rivers to store large quantity of water. Therefore British engineers started to build bunds with different soils , with inner core and outer casing. To control seepage through bund Clay/cohesive core or stone walls were built. (4) Due to advancements in civil engineering from 18th century onwards it was possible to construct dams across big rivers and to store hundred times more water than the traditional methods to use in times of distress. To achieve this various other materials beyond soil were considered. (3) (Fig. C/S of Improved Earthen Bund)



UNAKAL TANK BUND-HUBBALLI

As time progressed the demand to irrigate large area by storing more water became a minimum requirement and the traditional bunds were not suitable for that. Therefore while designing the large irrigation projects British engineers started to follow the European methods and techniques instead of traditional Indian approaches. Providing maximum possible water to maximum people is the basis of European model. (11) This forced the

engineers to consider stone as the primary material construction material rather than earth. In this back ground it is very interesting to know the development of large dams and huge reservoirs in India. In the following pages cover this aspects in brief manner.

For a non engineer it may seem to be very easy to build a dam across a river but technically it is challenging work. The adventure of Constructing high dams was started in Spain in 16th century . Since the required technical knowledge was not there , the dams were large in size than actually required. In technical sense large sized walls , beams , columns may not be safe. In the dams built in Spain the induced stresses at the dam bottom exceeded the allowable stresses under own weight of the dam. Therefore the responsibility of constructing high dams economically with safety came on the shoulders of the engineers. By research and study the high dams with appropriate shape and profile with minimum materials were found by engineering principles. (* Appendix : The major dams constructed upto 1930 C.E listed)

To build a high dam the theory of its structural behavior , technical explanations shall be available. The challenge of constructing high dam without sliding and overturning , without crossing the allowable stresses at bottom under the action of hydrostatic pressure was posed to the civil engineers. In any engineering work the economic aspects are always twined with technical demands. A solution which is technically perfect may not be feasible due to size, materials consumed , construction effort required and maintainace cost. Therefore civil engineers faced the challenge of designing the high dam without crossing the boundary of engineering principles and design parameters but at the same time economically viable.

In 1736 Belidore and Villareal gave the design principles of dams. Telford in his book 'Memorandum' provided the formulas and principles to calculate the loads on dams. In 1825 Gregory discussed the design of masonry retaining walls and water

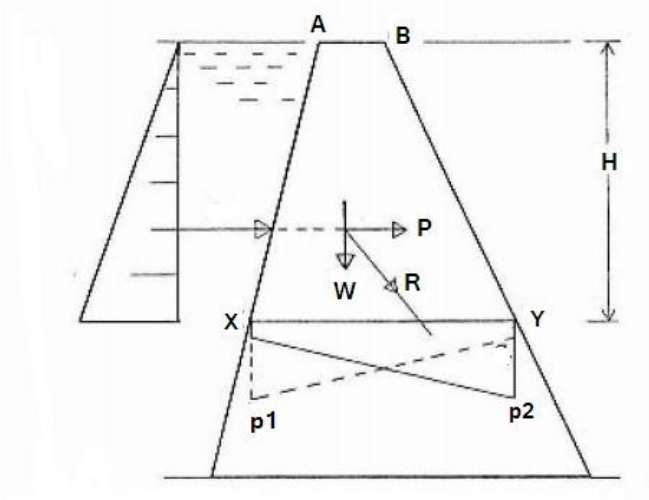
retaining structures. Moseley in his 'Treatise On Hydrostatics' (1830) 'Treatise on Mechanics (1834) and Mechanical Principle (1843, 1855) discussed the basic principles of dam design.(4)

In 1853 French engineer J. Agastein Torten De Sazilly in a journal called 'Annales des ponts et Chaussées' published an article under heading ' Nore Sur Un Type De Profile De Egate Resistance propos pour le De Reservoir De Eyata' and outlined the first two basic principles of stone masonry dams. They are -

(1) At any point in the dam body the induced stresses from self weight and external forces shall not exceed certain limits.

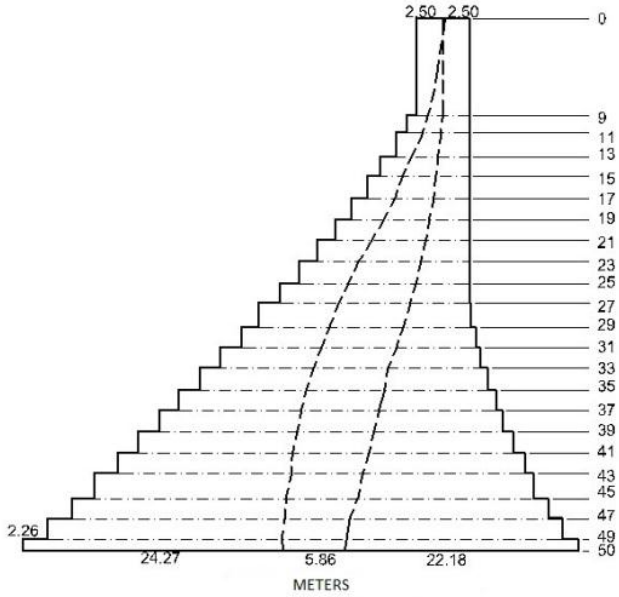
(2) The upper and lower portion of the dam taken on any horizontal plane of the dam shall not slide one over the other. Similarly the dam shall not slide on foundation.

The first of the above indicate the ' Load Bearing Capacity-Stress Principle' and the second 'Stable Safe Condition'.



P = HYDROSTATIC THRUST , W = WEIGHT OF DAM
R =RESULTANT FORCE , X-X = SECTION AT DEPTH H FROM TOP
P1, P2 = INDUCED PRESURES IN TANK FULL & EMPTY CONDITIONS

By using the 'Stress Principle' the induced stresses in the dam shall be determined under (1) Reservoir empty & (2) Reservoir full condition. Also Sazilly established that all stresses must be compressive in nature and uniform throughout any given cross section. This was known as 'Equal Stress Principle'. To achieve these conditions Sazilly worked out the profile of the dam in stepped form. Along with these if No Sliding and No Overturning conditions are added then all the conditions required to design a gravity dam will be fulfilled. In 1888 Edward Wegman proved that if all the listed principles are applied to (1) Reservoir Empty and (2) Reservoir Full condition then the dam will be safe under all possible situations. (Fig : Cross Section of Dam with Equal Stress Condition)

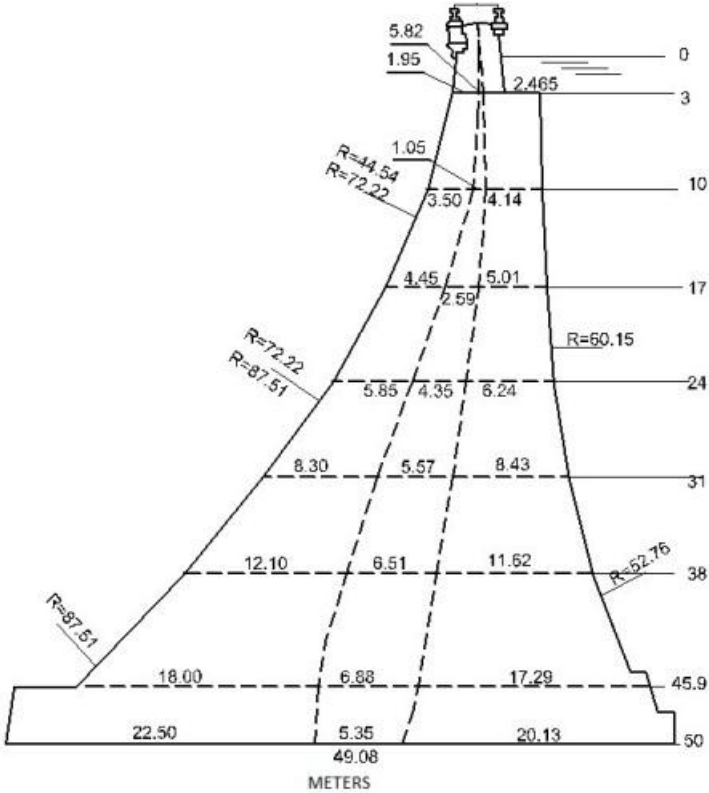


SAZILLY DAM CROSS SECTION

The region near the river Loir in France was submerging during floods . The challenge to control the flood and utilize the flood water for drinking by storage was thrown to the engineers. To achieve this it was inevitable to construct a dam exceeding 50 M . It was also found that the earthen bund of this height was not safe and only stone masonry dam is a feasible solution. Engineers Delecro and M.M Graeff were requested to evaluate the feasibility of constructing such a dam and outline the design principles. Delocre demonstrated that instead of the proposed stepped profile of Sazilly if the upstream and downstream faces are profiled to a suitable curvature then not only all the principles of Sazilly would be adhered and also the material consumption could also be reduced. By adopting the Delocre guidelines and recommendations 50 M high Furens dam was constructed in stone masonry. In October , 1866 Delocre published these principles in journal 'Anals De Pntas et Shauses'. Through this the complicated mathematical formulations of Delocre for dam design principles were spread to the engineering community. (3)

Furens dam was the tallest dam of those days and was the first dam which was designed and constructed on civil engineering principles. The construction activity of this dam posed many challenges. The dam site was on elevated land and the work was restricted to 5 months from May to October. To convey large quantity of material railway track was laid on the dam. The rail line was raised as the construction reached new heights. The work which began in 1862 was completed in 1868, The details of design and construction of this dam were published by A. Graf in journal 'Annales des ponts et Chaussées' and through an article with heading 'Memoirs Sur La Pharme Du Propfil A Adaphtar Par Le Grand Barages En makonari De Reservoir '. This dam was the

harbinger of new era of dam construction.[6] (Fig: C/S of Furens Dam)



FURENS DAM CROSS SECTION

[6] Before 1866 totally 47 number tall dams were built in France without any scientific basis.

Any dam spans across the river between two points of chosen elevation. If a river is flowing between two hills/mountains then it can be raised to required height between these natural boundaries. But practically it is not so straight forward because the dam needs stable foundation and such foundation available may not be available on a straight line. Then the dam has to be built on curved base plan. In such a situation the technical question arises whether such dam acts as arch between the two supports and what are design principles which governs it. Delocre and Pelletriyou considered this situation and provided the solutions for it. Delocre demonstrated that when the thickness of the dam is less than one third of the radius of curvature of the dam at top then it behaves as an arch. Pelleteau argued it to be half of the radius of curvature. Thus these two engineers clarified the behavior of dam which is curved in plan and abutting at ends. By the effort of these engineers by 1870-75 the standards for design of masonry/concrete dams were established. On basis of these the design standards for (1) Size Stone Coursed Masonry (2) Size stone Coursed masonry for faces with uncoursed rubble masonry in core (3) Uncoursed Rubble masonry 4) Concrete dams were developed.

Some British engineers who were very enthusiastic to build tall dams and store water felt that the earthen bunds are not suitable for that. Capt. W. Jones (1855) & Capt. Wingate (1853) who were working as engineer in Rohilkhand and Belagavi proposed local available materials for dam construction. Engineer Fife of Bombay presidency was very eager to build a tall dam for drinking water and irrigation. F.D Campbell was planning to build earthen dam near Ekrukh near Sollapur. Fife observed that the cost of this was same that of stone masonry dam. The attempts made by Fife to build stone masonry dam were not realized.

Even though French engineers established the principles of gravity dams it seems that British engineers did not know them. British engineer and professor William John Mecaurn Rankin in his books ‘Applied Mechanics’ (1858) and ‘Civil Engineering’ (1862) gave guide lines for design of stone masonry dams. These guidelines

were very similar to the principles put forth by Moseley in 1830. The 'Pocket Book ' published by Molesworth in 1868 had the design of water retaining walls. Even though lot of technical discussions were made before 1870 regarding the design of masonry dams , it is not clear that which guide lines or formulae were followed by British engineers to build earthen and stone masonry dams. (4)

To supply drinking water to Poona town a barrage was constructed in 1848. The sewage of Poona city entered this reservoir and the water was polluted and non-potable. As a solution to this in 1865 engineer Fife prepared a project report to build a dam 10 KM above this barrage , near Khadakawasla. This project covered both drinking and irrigation requirements. A dam 28.7 M high from river bed and 32.6 M high from the bottom of foundation was designed. Construction was started in 1870 and was finished in 1879. From this it was proved that without using earth the dams could be built economically with stone masonry. After filling of the reservoir it was felt that the dam has slided slightly. To check the sliding Fife added an earthen bund on downstream face of the dam. The further studies confirmed that the dam has not slided and but due to temperature effects some such movements were seen. [7] (4)

When Fife was thinking of replacing earthen bunds with stone masonry dams engineer E.L Asher who was in Ajmer explained the design principles of masonry dams in 1870. The suitability and adoptability of these were reviewed by T.Hingham. Deputy chief engineer of Madras , George Gorden designed 53 M high Stone and brick masonry dam for drinking water for madras city and irrigation. In 1869 George Gordon has proposed the stone masonry

[7] The waste weir of Khadakawasla dam had discharge capacity of 2775 Cumecs. In 1961 Panshet dam (Tanaji Sagar dam) which was on upstream initially cracked and ultimately breached releaseing huge quantity of water into the river . This water flowed over the waste weir of Khadakawasla dam which did not have the capacity resulting in the collapse of the dam.

dam for Masur reservoir. Fife wanted to build a high stone masonry near Roksan in Khandesh. Since the firm foundation was not available and the river bed was laid with sand this project was abandoned. (4)

When Khadakawasla dam construction was in progress Fife came across the article published by Dolecre and M.M Graff in 1866 through journal 'Annales des ponts et Chaussées'. When he read the article he immediately realized the mistakes done by him in designing the dam. He was convinced that the principles laid by French engineers were very scientific , they assured safety along with economy. Fife was disturbed for the fact that he haD taken up the dam design without knowing the advances made in other countries and also that his dam is less safe and more costly. Therefore he translated this article into English so that the engineers know the theories presented by French engineers. This article made British engineers in India to understand the principles of design of stone masonry dams. (3.4). The dam designed by Fife using Rankine principles , formulas and those of French engineers were available to engineers which brought new knowledge. The translation made by Fife was available in Royal Engineers' library in 1872. (4)

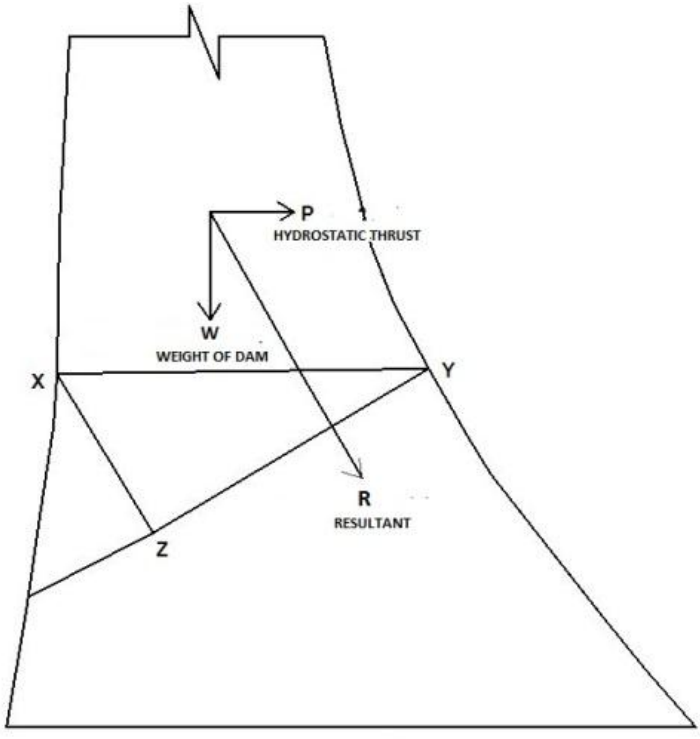
At this time Capt. Hector Tulloch had designed earthen dam for Vihar reservoir to supply drinking water to Bombay City. He believed that stone masonry dam would be very costly and require large number of skilled workers. There were hot debates in engineering circles on the designs made by Hector Tulloch. This forced Tulloch to search for alternate ways and came to know the article translated by Fife. With the permission of higher officers and administrators at higher level of Bombay presidency Hector Tulloch wrote a letter on 18/10/1870 to W.J Rankine who was the professor of civil engineering at University of Glasgow. Along this letter he had sent article translated by Fife , designs made by him and requested to review these and comment. (3,4)

On 9/2/1871 Rankine replied to the Hector Tulloch in which he expressed that even though the principles outlined and formulae developed by French engineers were correct , they need some modification. In coming days these modifications were came to be known as Rankine's Principles. The two additional principles suggested by Rankine in his reply are : (1) For a gravity dam to stand safely against overturning and sliding under the action of hydrostatic pressure , incidental forces and self weight , then the resultant of all these forces shall pass within the middle third of the dam base. (2) Tensile stresses shall not be induced at any point in any given horizontal cross section. By applying these two additional principles Rankine had modified the designs made by Hector Tulloch. The complete letter correspondence , technical details were published in journal named 'Engineer' under heading 'Report On The Design And Construction Of Masonry Dams' in 1872. These were first included in the book 'Manual Of Civil Engineering' brought out by Rankine in 1877. [8]

The design concepts of French enginers, the modification to them as suggested by Rankine were included in the Hand Book published with title ' Roorke Treatise On Civil Engineering' by Roorke Thomasan Civil Engineering College in 1873. Through this it reached the students and was included in curriculum. Some engineers did not agree the Dolecre proposals as well as modification suggested by Rankine. In 1872 Russell Atkins did not have confidence of designs prepared by Fife by adopting these principles. Engineer Playfair who succeded Fife was of the opinion

[8] In 1877 severe famine hit Madras presidency forcing British government to take care of the affected people. Some Brtitish officers (Lord Whiten) felt that in name of famine locals were exhausting funds without contributing any thing to the exchequer. Therefore he suggested that instead of giving free food and other material help , to employ the locals in a dam construction. Fife who prepared the project report to build a dam near Solapur waited until 1878 famine to take up the work. 19000 collies were employed as part of famine work to construct the dam. When famine ended prisoners were replaced.

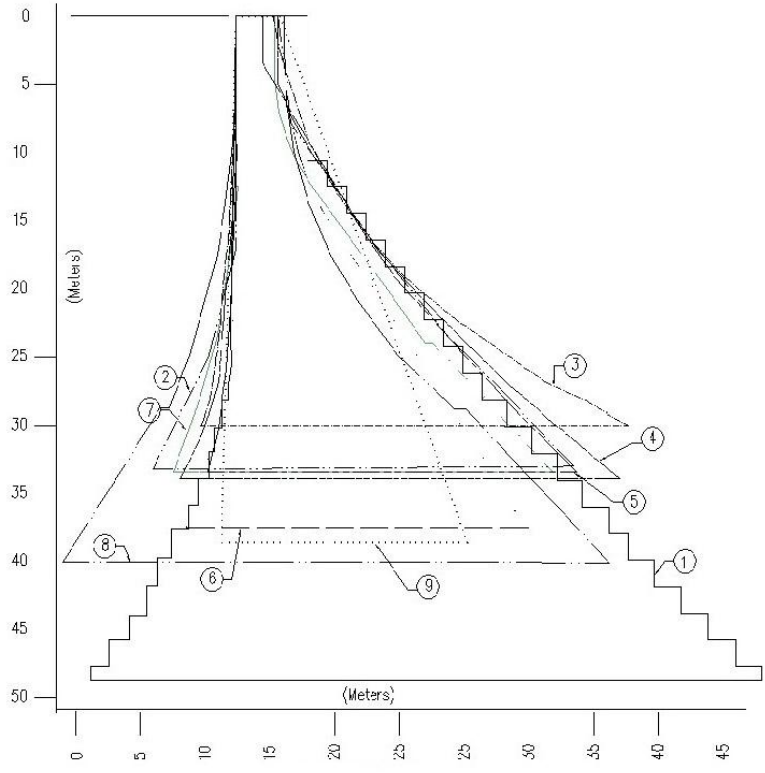
that the concepts followed by Fife are very 'Bold' and hence more thicker sections were necessary for safety . (4)



XY=STRESS PLANE (SAZILLY, DOLECRE, RANKINE
YZ= PRINCIPAL STRESS PLANE (BOUVIER, UNWIN)

M.Bouvier compared the designs of Sazilly, Delocre , Rankine and concluded that all these principles are not correct since they assume that the maximum stresses are induced on the horizontal plane. Instead the maximum stresses are induced on a plane which is perpendicular to the Resultant of Hydrostatic Force and Self Weight of the dam. He also indicated that as the face of dam inclines more the induced Stresses will be higher and introduced the concept and method of calculating the Principal Stresses.

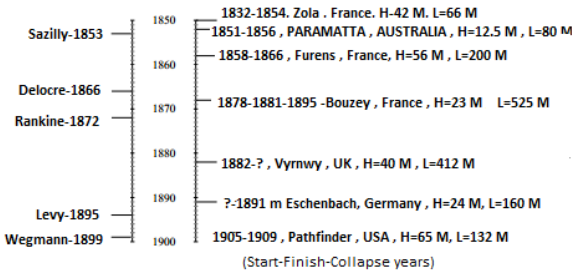
Even though the formulae proposed by Sazilly , Dolecre , Rankine are very clear but they were very complicated. In 1876, 1877, 1899 M. Pelletreau published articles simplifying these methods in 'Annales des ponts et Chaussées'. But these were not applicable to dams of all profiles. Therefore M.De Beauve developed graphical methods to solve the equations. W.B Coventri and others also introduced methods to solve the complicated equations. Molesworth developed methods to solve Bouvier equations. Engineers were using these simplified methods as per their convenience. In India. British engineers started to design and build large dams using Dolecre , Rankine , Molesworth etc., methods. Some engineers preferred Bouvier equations.(Fig : Cross Section of Dams by Different Approaches)



(1) SAZILLY (2) DELOCRE (3) RANKINE (4) BOUVIER (5) MOLESWORTH
(6) HARLCHERS (7) CRAGNOLA (8) KRANTZ (9) KHADAKAWASALA

DAM PROFILES - VARIOUS APPROACHES

Concept Pioneers **DAMS**

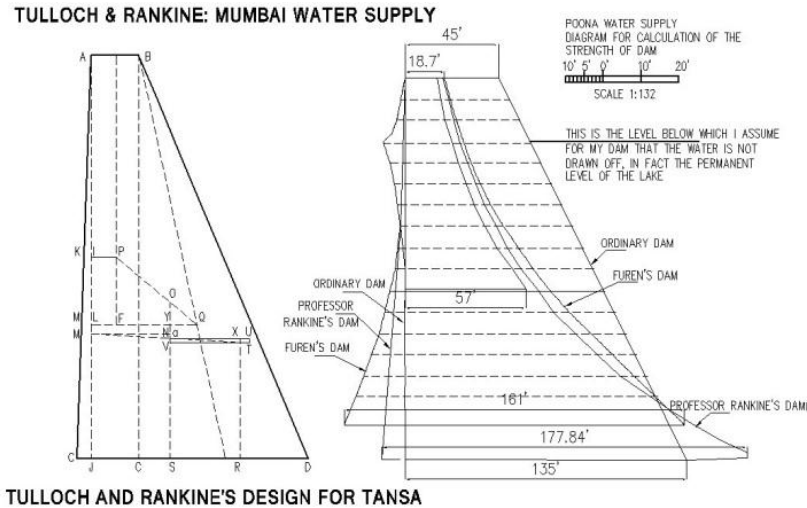

Sazilly-1853
Delocre-1866
Rankine-1872
Levy-1895
Wegmann-1899
1850
1860
1870
1880
1890
1900
1832-1854. Zola . France. H-42 M. L=66 M
1851-1856 , PARAMATTA , AUSTRALIA , H=12.5 M , L=80 M
1858-1866 , Furens , France, H=56 M , L=200 M
1878-1881-1895 -Bouzey , France , H=23 M L=525 M
1882-? , Vyrnwy , UK , H=40 M , L=412 M
?-1891 m Eschenbach, Germany , H=24 M, L=160 M
1905-1909 , Pathfinder , USA , H=65 M, L=132 M
(Start-Finish-Collapse years)

Development of Concepts & Construction of Gravity Dams

The designs done after 1880 utilized the established concepts and expressions of the time (Dolecre, Rankine). The 38.7 M high , 920 M long Bhatghar dam built across Elavandi river in Bombay presidency followed these design approaches. Initially Bhatgarh dam was designed as Uncoursed Ruble Masonry structure. But through tests it was found it was possible to manufacture concrete of good quality with cement. Therefore concrete was used where the induced stresses were below 0.42 MPa. The design of this dam was done by Arthur Hill , assistant to chief engineer J.E Whiting. The Graphical Methods developed by Molesworth were used. For the first time 15 under sluices to remove the silt were provided in the body of dam. The reservoir formed by the dam was named ' Whiting Reservoir'. Khadakawasla and Bhatghar which are 40 KM apart built with time gap of 20 years provide the comparative outlook of the dam designs. (4)

Through Tulloch deep discussions were started regarding the designs but the projects proposed by him were not taken up. Water to Bombay city was supplied from Vihar and Tulasi reservoirs. By 1884 these sources were unable to quench the thirst of the city. As a solution to this permission was granted to construct a 26 M tall Uncoursed Rubble masonry dam designed by Rankine modified method across Tansa river 90 KM away from Bombay. Bombay City civil engineer Reezam Walten designed the dam utilizing Bouvier-Molesworth graphs. The designs were sent to scrutiny of the committee headed by Fife. Hill one of the committee members who reviewed the designs concluded that Bouvier-Molesworth method is economical than Rankine method and Tansa dam is cheaper than the similar dam built in Wyrvy in England. Tansa dam of 36 M tall . 2804 M long with 503 M long weir was of uncoursed masonry. Originally designed for 41 M height was restricted to 36 M in first stage of construction. Locally available basalt rubble less than 150 mm and 'kankar' lime mortar in place of cement were used to achieve economy. The compressive strength tests on kankar mortar were conducted on 75 MM sized cubes. Some cube samples were sent to Kikaldi Laboratory in London for compressive tests . Even tough there

were variations in lime mortar strength , the achieved strength was satisfactory for adoption in construction. The actual work began in January, 1886 and was completed on 31/3/1892. (4) (Fig: Cross Section of Tansa Dam Designed by Tulloch)



TULLOCH AND RANKINE'S DESIGN FOR TANSA

The trend of building tall dams spread from Bombay presidency to other parts in various degrees. In 1855 Capt. Richard Strachey has prepared the irrigation report of Bundelkhand region. In 1868 the Executive Engineer of Bundelkhand Lt. F. Home proposed a barrage across Betwa river which was supported by Chief engineer Col. W.W Greathed . At this time Richard Strachey who rose to the position of Inspector General of Irrigation knew that in Bombay presidency 7.0 M tall stone masonry dam was built by Fife near Kurar and suggested to build similar dam across Betwa also. In continuation of this Lt. Arthur H. Baggey identified four suitable locations and submitted the report on 27/11/1869. The designs made by Arthur H. Baggey followed those proposed by Rankine in 1858 and 1862. The Dolecre design concepts , the construction of Furens dam in France were known to Superintendent Engineer Clinton Anderson. Thus Clinton rejected the designs prepared by

Baggey as they were oversized and asked him to redesign the dam in line with Dolecre principles.

The South West office of the chief engineer which was observing all these developments demanded further details. The James Hair who was the Superintendent Engineer of Bundelkhand region gave details of ruble masonry dam which was slightly curved in section to be built using kankar lime and port land cement . This was supported by Greathed but Brownlow argued that for stability ,down stream profile shall be straight as a wall and upstream profile shall be curved in exponential terms. Other engineers in Betwa region argued that the entire dam cannot be built with ruble masonry and hence outer faces shall be in built in coursed masonry. Col. J.Crofton , Inspector General Of India did not agree to this and directed Baggey to build dam in uncoursed masonry as in Bombay presidency. Greathed did not agree to this. Regarding Betwa dam there were varied opinions and controversies among Betwa irrigation department , South west Irrigation Department and Central Govt. which continued up to 1880. In 1881 Maj. Western started construction of dam near Paricha. After some time he abandoned this site and shifted near to Khurda adopting the curved face in section as proposed by Hair and Modifications suggested by Brownlow. Thus 17 M tall dam was completed on 29/9/1885.

Near Jabalpur across Khandari stream 23 M tall dam was built in uncoursed masonry using available basalt stone and mortar. This was designed by J.C Anderson as per Rankine equations and some modifications were made in construction technique by Col C.M Browne. In 1881 J.G. H Glass started the work and completed it in 1884. In 1850 Capt. Henry Ramsey constructed small dam across Bhimtal. In 1870 in place of this an earthen bund with rubble core was built. There were doubts about the safety of this. The dam was washed away due to heavy rains of 1892. New dam was proposed which was started in 1892 and completed in 1893. Bhimtal dam was designed as per Rankine equations. The 19M tall Muchukhandi

dam near Bagalakot of Karnataka and 15 M tall Bhatodi dam near Ahmad Nagar were also built. (4)

Pennycuick initially envisaged to build Periyar dam completely in concrete. Afterwards due to availability of sufficient quantity of rubble it was decided to provide Size stone Coursed Masonry on faces and fill the inner core with concrete. Doubts were raised regarding the uneven settlement that may occur due to difference in these material properties. Pennycuick answered them successfully . Pennycuick was much worried about the construction of 2000 M tunnel which diverted Periyar water to Vaigai valley rather than dam itself and concentrated his efforts to it.

Pennycuick felt that the area where the maximum stresses are induced as recognized by Bouvier are based on assumptions and not on reality and also more material would be consumed when Bouvier-Molesworth approach is adopted. Hence he made some modifications in Bouvier-Molesworth solutions. Pennycuick and Smith enlisted the defects in Rankine and Bouvier approaches as below-

(1) Sazilly , Dolecre, Rankine Methods are not perfect and they always does not ensure safety.

(2) Sazilly and Dolecre method are highly mathematical , Rankine approach provides general solutions. Engineers refrain to use these methods. Bouvier method searches for the highly stressed points on the outer and inner face of the dam. It is easy to do that , therefore Molesworth has adopted that method.

(3) Considering the existing dams in Span , French engineers has estimated the induced stresses in masonry in range of 0.65-1.5 MPa. This is less than the true capacity of masonry. Therefore the dam design based on assumed lower capacity of masonry has resulted in increase in dam size and economically costly. To escape from this situation French engineers has adopted the thin sections. In such sections even though the stresses are in safer limits at the

bottom part of the dam , the top portion may be unsafe due to induced tensile stresses. This is more dangerous.

(4) French engineers have reduced the size of the dam to achieve allowable maximum stress in dam which in effect ensures economy. At the same time tensile stresses that may be induced on upstream side has been considered. It is easy explain the dam behavior which is standing safely but It is not easy to design a dam which undergoes various conditions , situations during construction. Therefore dam design shall include these varying parameters and modified accordingly.

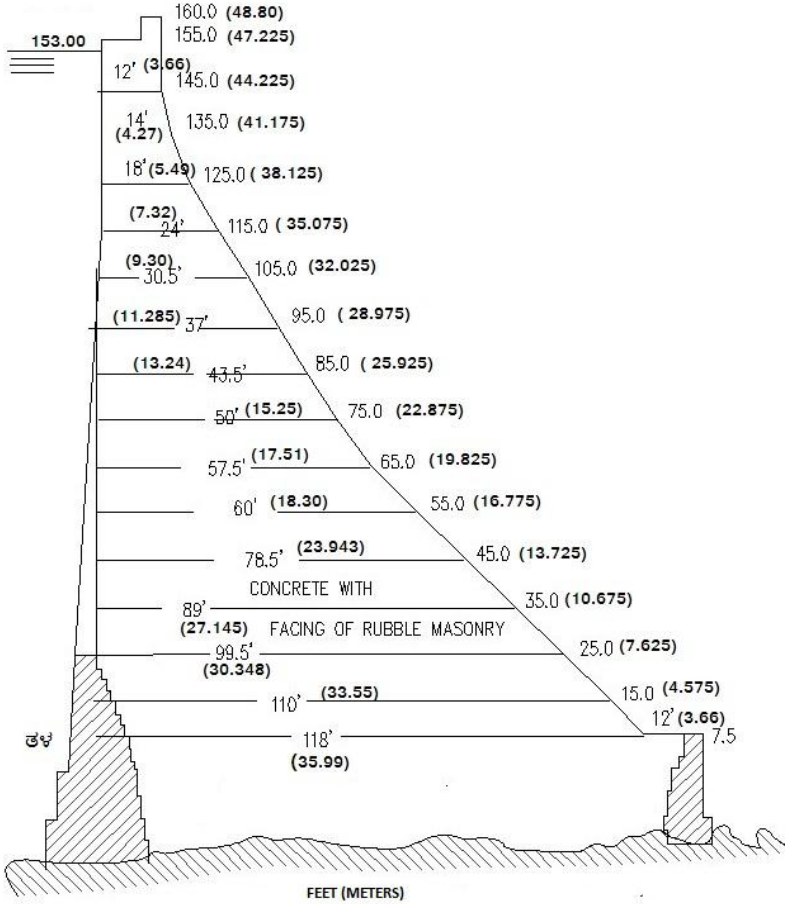
(5) The equations are developed considering the water pressure on upstream side but the water on the downstream side is not considered.

(6) In rear cases heavy floods may induce higher stresses than those considered in design, Due to this in 1881 Habra dam collapsed.

The points were explained in the Periyar report of 1892. Rankine has suggested the Toe and Heel stresses as 0.11 MPa and 0.09 MPa. Instead of these values Pennycuick restricted them to 0.09 MPa. In Pennycuick design the Middle third rule of Rankine under Reservoir empty condition was slightly crossed the limits. To know the impacts of these modifications made by Pennycuick , the additional chief engineer of Madras division J.J Halstead sent them to review of Molesworth. Molesworth defended his approaches through detailed calculations and declared that his methods are erroneous towards the safe side. Brownload supported Molesworth. After this incident to familiarize the Bouvier-Molesworth methods in department they were printed and distributed to engineers. (4)

The slight seepage through the concrete portion of Mulla Periyar dam was observed and once again the discussions started. G.T Walt who was working in Godavari region in 1887 , conducted various

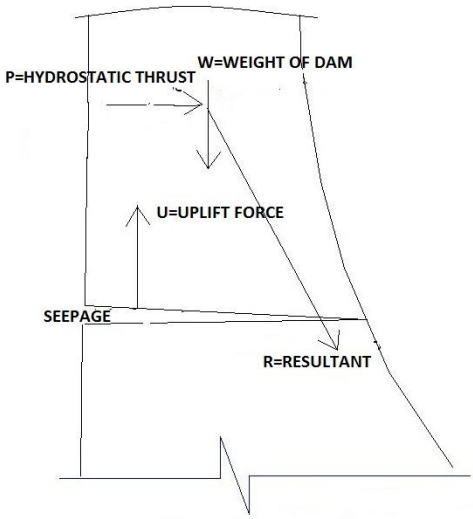
studies , tests and declared that it is impossible to construct totally water proof dam (Fig: C/S of Periyar Dam)



PERIYAR DAM CROSS SECTION

By 1900 there was wide consensus that Rankine Equations shall be used for dam design. It was documented as Standard procedure in the book ' Design Of Irrigation' brought out by Blig in 1907. But the controversies were not yet over.

Any dam built using soil , stone , concrete or any other material will not be totally water proof. Therefore water seeps in the dam foundation and faces. The pressure exerted by seepage water will be directly proportional to the depth of water stored. This force not only reduces the weight of the dam but also may induce tensile forces on water face. Such forces are called as Uplift Forces. Sazilly, Dolecre , Rankine approaches does not consider such conditions. Pennycuick and Smith were imagining some situation like that even though exactly not that. Therefore 'admired baby' of dam design for many engineers which was born in France was forced to look into itself from an incident that occurred in France. (Fig. Uplift Forces and their Effects)



UPLIFT FORCES & EFFECTS

Bouzy dam in France was designed in 1876. It faced one or the other from the day one itself. On 27/4/1895 Bouzy dam collapsed. The designs were reviewed and it was concluded that not considering the uplift forces due to seepage is the sole reason for its failure. [9](50,55,68)

After failure of Bouzy dam W.C Unwin started the comparative study of all the dam design approaches. All the theories developed before French engineers dominated the scene advocated the safety of dam against sliding and overturning under the action of hydrostatic pressure and uplift forces due to seepage. But French engineers to achieve economy neglected such condition in any part of the dam. Unwin showed that when the tensile forces are induced on the upstream side face of the dam the cracks will appear in the dam body. The water enters these cracks inducing pressure and widens the cracks and ultimately resulting in failure.

After the failure of Boozy dam , in same year Miley published an article titled 'Cuelcues Considerations Sur La Construction De Grand Barages ' in journal 'Academi De Science' and declared that at any point in dam body the compressive stresses shall be greater than the hydrostatic pressure at that level. Otherwise when the cracks are formed due to temperature, shrinkage or any other reason than water enters into it inducing tensile stresses and ultimately results in dam failure. He also suggested the distribution of uplift forces below the dam body and urged to consider them in design. (70). If these forces are considered then the size of the dam will be many times than that proposed by Sazilly, Dolocre , Rankine. Therefore suitable arrangements shall be made to drain the seeped water at foundation and as well as body at different levels. T.Houksley & G.Diocon who knew this before the collapse of Bouzy

[9] In 1886 when Panshet (Tansa dam) dam work was started , attempts were made to consider the uplift forces on the foundation of dam due to the seepage of water through the cracks and crecvices of the rock bed.

dam provided 26 drain paths of 0.23-0.3 M size on upstream face of dam in Wyrny dam near Liverpool. Intz of Germany who designed Eshkenbach Dam in 1891 has provided waterproof layers on upstream face of dam along with drainage paths. On this principle dams were constructed in Germany. (70)

When engineers to serve in India were selected preference was given to those belonging to Royal Engineers Institution of Chatam in England. George Kenneth Scot Moncrieff of the this institution visited India in 1899 and had prepared a report. This report was appendix to the 'Water Supply' book which was the text book for new engineers. The books 'Water' and 'Structural Analysis ' authored by Moncrieff had dam design topics in which he has discussed the Rankine and Bouzy dam failure. Therefore for British engineers who were deputed to India in the beginning of the 20th century all the aspects of dam design were known. Garet who knew Bouzy dam failure , Bouvier , Pennycuick and Unwin discussions designed the Agar dam of Rajasthan considering uplift forces in 1906.

By 1890 in India large dams like Bhataghar , Bhagatpur , Tansi , Periyar dams were completed and others were in construction stage. With this irrigation engineering activities got preference. To study these activities and to implement them in USA Herbert M. Wilson was sent to India. He reached Bombay on 13/1/1890 visited important project sites in India up to 31 March and prepared a comprehensive report which provides complete picture of Indian Irrigation. This was published in 1890-91 by 'Director Of The Unite States Geological Survey' under the title ' Irrigation works of India '

While returning back to his country Herbert M. Wilson visited Eden and also saw construction of Barrage De Nile' in Egypt . He visited various water supply projects in Italy and France. With these he made complete report and published ' Irrigation In India' in 1890-91. The second edition of this book which included the new developments in Indian irrigation came out in 1902. This provides

the complete picture of irrigation activities in India in last decades of 19th century.

In 1899 Edgar Wegman brought out 'The Design And Construction Of Dams Including Masonry , Earth , Rock fill And Timber Structures , Also The Principle Types Of Movable Dams' which covered the history of dam design and contemporary practices. This became a Hand Book for Indian engineers for Irrigation Projects and dam Building.

If we see these in totality it is very clear that by end of 19th century the British engineers in India knew in and outs of dam construction.

2.2 Tale Of Tails

When a glance is made over the irrigated and non irrigated regions of India the contrasting pictures emerge. While One view is pleasant with lush green landscape of sugar cane , paddy , plantains other side is scorched unattractive water starved low yield dry land of millets and such crops. Since time immemorial the achcut below the tanks comprised of wet crops such paddy , sugar with high water demand and other areas with crops like cotton , millets etc., of low water demand which solely depended on rain. During British administration the prevailing practices India were deviated and attempts were made to supply water to dry crops which were otherwise at mercy of gambling rains. Such crops were recognized as irrigated dry crops.

British as well as in independent India the central and state governments strived hard to expand the irrigated area through hundreds of projects. Also, Hundreds of such projects are awaiting clearances from governments. But day by day the water issues are becoming complex and the various states are tangled in bitter disputes to get their 'fair share' for irrigation needs. The seed of this problem was sown with construction of large capacity storage dams. No irrigation project in India is successful in providing the required water to initially designed area. In most of the projects

only 50 % of the designed area in Detailed Project Report is able to get the water in correct quantity at appropriate time. Many engineers have argued that the loss water during conveyance is the main culprit which can be fixed by lining the canals with concrete. Along with this minimizing the interference of government , training and engagement of the stake holders to manage the water in scientific way are the other ways to improve the situation. But the problem of proper distribution of canal water has its own historic burden which cannot be relieved so easily.

After war of 1857 the role of British changed from traders , businessmen to administrators. As a result of this they were forced to face famines and plan for irrigation. The works to be taken up to alleviate the problems of famine and irrigation of large area require huge investment which naturally demands study of financial implications. British calculated the interest rate and returns on the investment made on irrigation projects and executed such projects which were attractive. Except in Ganga-Yamuna region nowhere else the interest rate was attractive. The series of famine between 1860-1870 made British to think differently. Even though the interest rate made on the investments in south India were not attractive but when compared to the money spent on people during famine the former was the better option . This encouraged British government to store water in large quantity by building large dams and facilitate irrigation.

The large irrigation projects many times were not progressing as they were planned. Arthur Cotton wanted to build dams across south Indian rivers to facilitate irrigation and inland water ways which he considered cheaper than railways. Based on the concepts of Arthur Cotton in 1858 Kurnool-Cudapa canal work started. (KC Canal). The aim of the project was to build dam across Tungabhadra river near Kurnool and convey the water from it to Pennar river which is 420 KM away. To take up this work under the leadership of Arthur Cotton a private company named 'Madras Irrigation Company' was formed. With guaranty from government it collected 1 Million pound through public shares in England

assuring 30 % return. By 1860 the company was bankrupt and works taken up were nowhere. Madras government was forced to take the burden of this. But it was impossible to recover the interest amount from farmers by taxing the water. After this British government kept strict vigilance on such projects.

After construction of Grand Anicut Madras government was ready to provide water to farmers at free of cost for first 5 years and at half the cost for next 5 years. But farmers were not attracted by this. Large farmers felt that instead of getting water by paying money it is better to grow dry crops in traditional way which is more profitable. This raised doubt in British government that whether the farmers will participate in their irrigation projects or they stay away from them. After 1879 when they were confident of success of irrigation project the investment started to flow.

From technical , social , commercial view points providing water to the maximum area , to the maximum people is the basis of irrigation policy. But this ideal was never achieved. Whatever may be the government policies , rules , economic thoughts since from days of British the farmers on the upper reaches of the canal were interested in wet crops and the farmers on lower reaches were deprived of water which is famloulsy known as 'Tail end problem'. (5.25) Answer to the question why such a situation arise is in the very policy of irrigation projects.

Any large irrigation project has its own financial burden. To lessen this burden the stored water has to be sold to the farmers as water taxes. The quantity of water to be sold depends upon the nature of soil and type of crop. It is very difficult to decide whether water taxing shall be on the quantity of water sold or on the nature of crop and its area. It is extremely difficult to decide the quantity of water used by each farmer. Therefore British fixed water taxes on the nature and area of crop. (5)

Providing water to all in the achcut area as per the requirement is the ideal aim of any project. But it is not easy to achieve it. From 1874 Mutha and from 1885 Nira canals started to supply water.

Under Khadakawasla reservoir irrigation facility for 75000 acres was planned. By 1890 only 1/10 of that was brought under irrigation. It was not possible to irrigate even 30 % of the stipulated area even after 30 years of construction of dams and canals. There were unique reasons for that. Farmers always did not avail canal water. Only during famine farmers purchased water to sustain their dry crops such as jowar , millets , cotton etc., Also they did not extend their irrigation area on the assured availability of canal water In large part of the achcut area black cotton soil predominated. This soil retains water for a long duration. Even with scanty rainfall dry crops can be grown. Therefore farmers waited for the rains until the last minute during which there was no demand for the canal water. When rains failed then at last minute farmers were hastening and eager to take canal water.

There was one more invisible fact. During good season reservoirs will be full when dry crops does not need water. Good rains brought good yield increasing the supply in the market and bringing down the prices. In such a situation it is not wise to use take taxed water from canal. Farmers were ready to purchase supplementary water from canal which was deficient from rain and did not wanted to pay on the basis of nature of crop and area. British were in a fix and they did not know how to face this situation (5,25). Attitude of some farmers was different. They thought that any how we have to pay for canal water then why should we restrict ourselves to dry crops instead let us grow wet crops. This attitude was a fatal blow to the concept of providing water to the maximum area to provide protection against famine and forced British to allow commercial crops under irrigation.

When Nira canal started local farmers did not purchased the water. Knowing this Mali's of Sasalwad region came to the achcut area , took the lease of lands from local farmers , purchased the water from canal and started to grow wet crops like paddy and sugarcane. For local farmers leasing the land to Mali's was attractive than themselves purchasing the water , tilling , growing and getting profits through sale of produce. The areas which were

under irrigation but for which owner farmers were not interested to purchase canal water were easily available to Mali's in large extent. If sufficient quantity of water is available growing sugarcane is easier than growing cereals ,pulses and vegetables. If jaggery or brown coloured sugar is made from sugarcane then there is no risk of perishing like vegetables and there is advantages of waiting until good rates prevail in the market. Hence Mali's got lease of large tracts of land in Nira canal achcut and started to grow sugar cane and also they were ready to pay higher taxes to canal water through which British government was assured of the good returns on their irrigation projects.

The problems of proper water distribution is not limited to dry and wet crops. There are many practical obstacles to restrict the wet crops and provide water to dry crops spread over large area. Following Malis, local Marathas and Brahmins convinced themselves that it is right to grow sugarcane instead of dry crops. The effects of this took many curious turns. For whom the dams were built, for whom irrigation facilities were provided were not interested to purchase canal water at all times. But the people who grew restricted wet crops were ready to pay taxes to the canal water. Thus the dilemma that whether to provide water to wet crops to get back the money invested on projects or to store the water in reservoir to protect the dry crops when rain fails haunted British government. The swing moved from dry to wet crops and ultimately government stood for wet crops which in due course became a right. (5,112)

In the years of elusive rain the situation worsened. As an effect of this in 1890 when great famine hit , the farmers on the upper reaches of the canal were growing paddy and sugarcane while the farmers of lower reaches were in famine camps. The purpose of Nira canal was to provide irrigation to 2 lakh acres of dry crops but by 1890 the sugarcane was the crop of preference. In the next year plague spread resulting scarcity of labors. Due to this sugarcane lost prominence. In 1898-1890 due to scarcity of rains sugarcane was cultivation was stopped. In 1902 the farmers did not take

water from canals as there was good rainy season and the canal irrigated dry cop area reduced from 17000 acres to 3000 acres depleting revenue to the government.

When both dry and wet crops were allowed water allocation problem took one more turn. When much water was flowing the farmers at upper reaches started to grow wet crops in the lands which were traditionally grown dry crops. This deprived of water at lower reaches. When famine hit , the farmers with dry crops were ready to purchase canal water but the farmers at upper reaches expected full water for their wet crops as in normal rainfall years . When the cost of dry animal fodder was costlier during famine farmers grew sugarcane indiscriminately. The fear loomed over that If enough water is not allocated to wet crops farmers who were ready to purchase water does not believe the government and will stop cultivation of wet crops which brought major revenue. Then during abundant rainy year to whom the water to be sold ? and how to recover the project cost ? Thus the allocation of water became a complex problem.

When the canal works of Nira were not completed water was easily available for sugarcane. In future years when more than 6 distributaries were completed , providing water to sugarcane became a herculean task. To find a solution to this situation Irrigation Commission of India sought the opinion of various irrigation circles. Sir M.V proposed Block Irrigation system. In future years irrigation projects were completed in Ahmed Nagar , Nasik , Satara . Sollapura areas. The local farmers who knew that Sasalwad Mali's who made money through sugarcane cultivation increased the lease amount for their lands. This resulted in the in the increase in market value of land. As an answer to this Malis moved to the newly irrigated areas where lease were available at lower amounts and started to grow sugarcane. Gradually in these areas also the Nira effect was repeated.

To face such an eventuality Fife fixed the discharge sluices at different levels. The sluices at the top most level catered for wet

crops while lower sluices for dry crops. As per planning the canals which fed dry crops were three times longer than those of wet crops. The dry crops needed water during deficient rain while wet crops needed water at all seasons. Relying on dry crops if water is retained then investment cannot be taken back. Without guarantying water allocation to wet crops revenue cannot be generated. In such a situation it was decided to supply water to dry crops in critical years and when it does not require then to be supplied to wet crops. (5)

After independence India has built hundreds of dams and in each of these tail water problems took new twists and turns. The powerful farmers at upper reaches started to grow wet crops in areas earmarked for dry crops without any restraint or fear. The election based politics in India , lack of political will failed to control this menace. Thus the tail water problems haunt India from north to south and east to west uniting country as one.

3. BHAGYA SHILPI : PROFESSIONAL LIFE

The mile stones in the professional life of Sir M.V can be listed from his book 'Memoirs Of My Working Life'.

(1) March 1884- Assistant Engineer , PWD Nasik – Beginning of Profession Life

(2) Transfer to Dhulia Sub Division .

- Construction of canal to Dhavarti Village , 56 KM away from Dhulia

- Construction of Siphon at crossing of tributary of Bankra river

(3) Overseeing engineer in absence of Executive Engineer / Worked as acting Executive engineer. Supervision of irrigation works in Khandesh and Nasik districts.

- Design of Dhulia Water Supply scheme including small storage reservoir and initial construction activities.

- Survey work to construct a reservoir on lower plains of hills in Samyak district

(4) Passed the departmental examination in practical engineering. Passed tests on proficiency in oral and written Marathi language. Promoted to second grade of Assistant Engineers.

(5) In next months was promoted to first grade Assistant engineer post which was vacant. Within 20 months of service life rose to the first grade of 500 Rs. monthly salary.

(6) Afraid of wide spread malaria in Khandesh requested for transfer. Sent to main office of building construction wing in Poona. Opportunity to learn about buildings and roads.

(7) In 1893 death of water supply engineer in Sukkur , Sindh province. With the assurance of additional monthly salary of Rs.

200 and house allowance of Rs. 50 transferred to Sukkur. (What was the salary of M.V in 1893 who drew the salary of Rs. 500 /month within 20 months of joining the services is not known) Admirations from Bombay governor Sandhurst , Sukkur Muncipal Corporation and Bombay government for the work done by M.V in Sukkur.

(8) Deputed to execute the water supply project for Surat. At the same time additional responsibility as Executive engineer for Surat & Bharuch districts.

(9) 1896 promoted to Superintendent engineer post, PWD , Poona Central Division. Execution of irrigation works under famine mitigation scheme. The review and modification of projects prepared by engineers of lower rank and advice to prepare reports for new projects.

(10) In April , 1899 transferred to irrigation department of Poona. Two large reservoirs of Bombay presidency were under this division and major portion of water was apportioned for irrigation. The responsibility of providing water to Kirki and cantonment which were the outer extensions of Poona and also providing sewage system to Poona city.

- Preparation of Technical hand book titled 'On the Irrigation Works In The Bombay Presidency excluding Sindh'. Introduction of Block System of irrigation.

- Between 1901-03 installation of automatic flood gates on weir of Khadakawasla dam to increase the storage capacity. Agreement with Ms. Geo Gahagan Co. to manufacture these gates and disagree to take any patent on these gates.

-1904 honored as 'Fellow Of Bombay University'. The responsibility of preparing the regulation of the university.

-1905 Along with responsibility of Sanitary Engineer , working and project report preparation in secretariate.

-Suggestions for rehabilitation of failed tank bund in Kollapura which supplied water to the town.

(11) Responsibility of providing water and sewage network for cantonment area of Eden. The upgradation of roads in cantonment , preparation of estimates.

(12) In 1907 temporary appointment to look over three superintendent engineers. At the same time responsibility of sanitation works in Bombay presidency.

-Formulation of Road rules.

- Preparation of report for water supply projects of Dharawada & Bijapur towns.

- Member of curriculum review committee of Poona engineering college.

(13) Offer from two states to take up the Chief engineers post. On this basis demanded the Bombay government to promote to chief engineer's post. When it became clear that it will not happen uneasiness set in and started to thinking of resigning from the government post.

(14) In 1908 decided to resign from Superintendent engineer's post , submitted resignation and went for foreign tour. When in foreign tour was called from Hyderabad Nizam to find solutions for flooding of Musi and Easi rivers.

(15) In 1909 retired from Bombay government services and beginning of the professional life as Consulting Civil Engineer.

(16) Returned from USA tour and from 15/4/1909 to November 1910 was engaged in designing the projects to control the flooding of Hyderabad city by Musi and Easi rivers. In 1913 Hyderabad government started to build dam across Musi river.

(17) Chief Engineer of Mysore state Mac Hutchin retired on June 1909 and M.V was appointed as chief engineer on 15/11/1909.

- Attempts to implement Block System of irrigation in Marikanive project.

- Design of sewage system for Mysore city.

- On 5/11/1911 project report to construct dam across Kaveri near Kannambadi was submitted and the foundation work started.

(18) Appointed as Mysore Diwan in November 1912

Objections from Madars government for construction of dam across Kaveri river (KRS dam) . To resolve the issue Tribunal was set up on 18/1/1913 under Harry Griffith as president. The final judgment in May, 1914.

(19) May 1918 , Beginning of construction of Mysore Iron & Steel Works factory

(20) December 1918 resigned from the Diwan post on own decision.

(21) 1922 – Inspection of ongoing works in Hyderabad state , technical advises.

(22) 1924- Head of Krishna Raja Sagara reservoir canal design and construction committee. Introduction of block system of irrigation.

(23) Head of committee for New Bangalore water supply Design and implementation. Chamaraja Sagara reservoir (Tippagonadana Halli reservoir) was the part of the project.

(24) Senior member of the committee for investigation of misuse of funds in Sukkur Barage construction.

(25) 1930- Study of the exisiting conditions and recommendation for improvement of Hyderabad city.

Works done as consulting Civil Engineer

1922 :The member of New capital Enquiry Committee constituted to study the pros and cons of shifting capital from Calcutta to Delhi.

1924-1925: Member of Bombay Rejuvenation committee and contributed in providing recommendations for infrastructure for Bombay city.

1926 : Member of Bombay Bay Enquiry Committee

- Recommendations for irrigation projects of Gwalior state and technical advice for reconstruction of failed Tigra Dam.

- Design of settling tanks for Hyderabad , Sindh province

-Suggestions for Nagpur water supply project.

-Suggestions for Goa water supply project.

- Improvement of water supply system of Bhavanagar with technical advice for supervision of failed earthen bund.

- Projects report for water supply and electricity to Bhopal city.

1929 : Member of the committee for investigation of misuse of funds in Sukkur Barrage construction.

1938 : Member of Bombay Irrigation Committee. Expert advice in preparing guidelines and policies for irrigation. The decision to implement block irrigation in all projects.

1939 : Preparation of project report to mitigate the flood effects in Orissa.

1947 : Resolving the technical differences which arose during construction of Tungabhadra Dam.

- Identifying suitable sites for dam construction in Saurashtra.

1952 : President of the committee formed to decide the location of bridge on Ganga river.

3.1 Background

There is lot of fanfare and myths regarding M.V. as an engineer. To list a few are (1) He was the most brilliant engineer (2) He was always enthusiastic to know the technical advances made in the world (3) He was knowing the advances made in civil engineering anywhere in the world & was implementing them in Indian projects (4) To acquire new technical knowledge he toured foreign countries many times. (5) The projects envisaged , the designs made , the reports submitted were unique and historical. (6) there was no other engineer to name who was equal to him. By seeing the works of M.V closely veracity of these claims can be examined.

The professional life of M.V can be clearly divided into two stages – as government engineer and private consulting engineer. His working life started as Assistant engineer raised to the level of superintendent engineer. M.V strongly felt that he had all the merits to raise to the post of chief engineer but he has to wait for it for long. Therefore he resigned before his retirement age came. Legally M.V was not eligible to get pension for his service duration in government. But considering his services Bombay presidency sanctioned him the retirement pension.

The services of M.V as government engineer were nothing new and they were routine technical jobs. Whether these jobs were big or small M.V did them with equal diligence. As he was in irrigation department in beginning years along with technical knowledge he gained the pulse of the people. This enabled to him as an engineer who can converse with people in their own language. On his own capacity and dedicated work at young age. M.V moved to higher

posts crossing over senior engineers. M.V used all these opportunities with devotion and efficiency. [10]

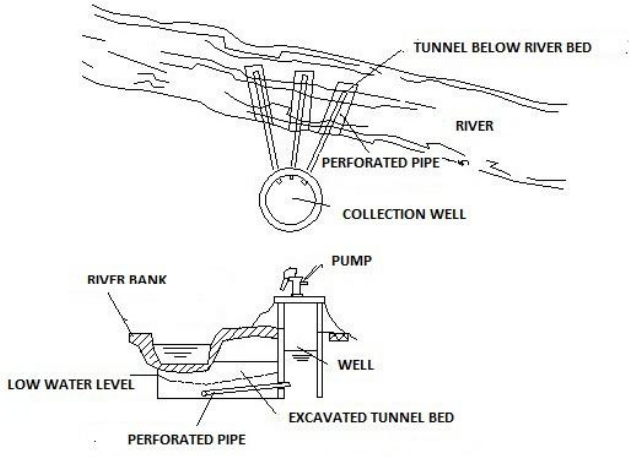
Beyond these facts there is no answer to the direct question that whether M.V really was a great engineer in technical sense or not. Because each one who has written about M.V depended on his own book 'Memoirs of my Working Life' and considered every work done by him – laying of pipes , construction , maintenance , repair of canals , design and execution of water supply schemes , buildings , roads , flood mitigation measures, design of dams , Block system irrigation , invention of automatic gates , Design and construction of KRS dam , Bhadravati factory – as unique and unparalleled. Until now nobody has attempted to check critically whether the M.V's achievements were really great or they are the result of fertile imagination that arose from the background pride of nationality and language. Is there any place for M.V in objective branch like civil engineering which does not consider any sentiments. In this book the works of M.V are evaluated critically on civil engineering fundamentals.

The working life of M.V starts from construction of siphon for canal which has to cross tributary of Panjra river as a part of water supply to village Dhavarthi ,56 KM away from Dhulia. M.V faces many challenges in it. Such field problems are very common and they are normal rather than exceptions in civil engineering. Completion of any project without problem is a rarity in civil engineering. Like other civil engineers M.V also faced challenges and was successful.

In 1894-95 M.V took the responsibility of designing and executing the water supply project to Sukkur town. Lifting of water from

[10] William Willcocks who was transferred to Egypt had said that, the promotion of any engineer to higher post is the discrimination of the government only and it does not depend on the seniority of service. It is not clear and no information is available to know the basis and parameters British government was promoting engineers.

Indus river to the supply units which were situated on a hillock near Edinburgh Churchill was the main work of the project. Drinking water has to be treated before it is supplied. Sukkur municipality did not have enough funds to establish filtration /treatment unit. Since the water in Indus was always muddy it was not possible to supply it directly. Since from pre historic times people did not take muddy water directly from river. They dug 1-2 M deep wells on the banks of the river. The filtration was achieved and mud was removed when water seeped through the sand of the river to the wells. M.V utilized this ancient technique and adopted the river sand as filter. Sufficient water was not percolating to such wells dug on the Indus river. Therefore M.V constructed cross tunnels to the well. The water which seeped through these tunnels was filtered and collected in the well. Thus without filtering, sufficient clean water was available for supply. Earlier on Tapati river same technique was adopted by another engineer by digging circular wells on the river banks and pumping it to drinking purpose. M.V scheme was similar to that. The technique adopted by M.V was neither innovative nor special. Sukkur Municipality honored M.V for his dedicated work. (Fig : Pecolation Collection Well)

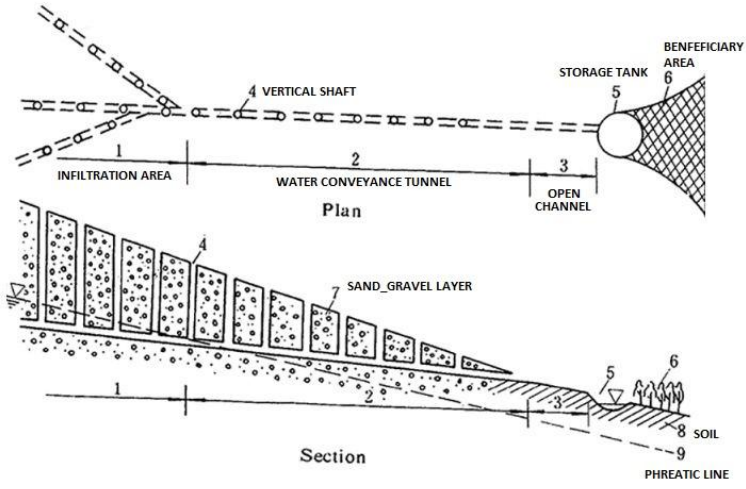


INFILTRATION WELL

Filtration capacity of any sand depends upon its grain size distribution, soil content in it and silt thickness. These parameters may change from year to year or season to season. Before considering natural river sand as filter whether M.V conducted any tests or just from general experience he used it is not known. We do not have any information as notes , observations , drawings regarding the actual method adopted , the level of filtration achieved , the acceptable standards of drinking water during those days etc., or quality of water supplied in European nations. If M.V's method was so admirable , technically correct and the results from it are satisfactory to the accepted drinking water standards and economical then why same method cannot be adopted to thousands of villages on river bank which are dependent on muddy river water. Nobody has tried to answer this.

In 1906 M.V took the responsibility of providing drinking water and sewage system to cantonment area of port city Eden along with classification of roads and preparation of cost estimation for up gradation. A hilly place 90 KM away from Eden was receiving sufficient rainfall. This water flew as steam through Lahej province and was disappearing in sand.

M.V prepared a project report to collect this water and pump it to Eden for drinking water purpose. But he did not participate in execution of the work. Similar techniques were used in Quetta region of Baluchistan since ancient times. The underground water percolated into the ground at the foot of the hills was collected through the tunnels called Kareja. From the foot of the hills 1 to 1.5 M wide 3-4 M deep wells were dug and these wells were connected by Karejas. The water collected in wells flowed down and collected at lower levels. Such karejas were 8-10 M apart. It was common that the Karejas which connected the series of wells were collapsing and obstructing water flow. M.V modified this and adopted for Eden and nothing new was in it.



KAREZ WATER COLLECTION SCHEME

3.2 Block Irrigation Ssystem

Flood of praises have flown for the concept of Block irrigation mooted by M.V. Except in couple technical papers nowhere discussion has be done on Block Irrigation system. What was the block irrigation system , was it successful can be known through the hidden records.

The toughest challenge faced by irrigation engineers in Bombay presidency was to balance and ensure interests of dry crop farmers who wanted canal water when rains failed and the wet crop farmers who were ready to pay for canal water at all times. To find a solution for this Indian Irrigation Commission was formed under the leadership of Colin Scot Moncrieff who was previously the head of irrigation department of Egypt. This commission travelled throughout India to search for ways to improve the irrigation in India.

Then M.V who was in charge of Mutha and Nira canals argued that the concept of providing water to large areas during the rainfall deficient years is wrong. The water stored through investment must bring back the amount and it shall not be stored for protection from famine which may come once a while. Water has to be considered as commodity of earning and not from consideration of famine. The projects which are aimed to provide water to irrigate large area during famine are meaningless. Therefore the preference must be given to wet crops which bring back the maximum retunes for the investments made and need not be worried about dry crops. What is the way for the farmers who grew dry crops during famine ? For this M.V answered candidly that they must earn and live as laborers in paddy and sugarcane fields. British rejected this M.V's proposal on the ground that it is not possible to provide work to thousands of farmers of dry area as labors in wet area and also British were right in ascertaining the fact that Indian farmer who owned land was rather ready to wait for next rain and never willing to work as labor in others fields. (5)

In upper canal reaches of Nira achcut area which was under in charge of M.V , sugarcane was the preferred crop. The economically powerful farmers near Poona started to use canal water recklessly on the argument that since they are paying for water tax they have absolute rights over it. Due to this tail end of canals ran dry. To control this menace Assistant Engineer V.S Vartak from Poona was striving hard and introduced 10 day water supply system. The powerful farmers opposed this and protested against the 'apathy' and anti people attitude of irrigation department. Eventhough engineers were strict to control the misuse and overuse of the canal water , the farmers on upper reaches paid bribes to the lower grade workers of the department who controlled the distibutories. Government was in a fix and requested divisional offices to suggest the methods to improve water distribution system and the ways to get the revenues. (5)

To resolve the tussle between irrigation department and farmers , M.V called a meeting of farmers at Ferguson College , Poona. The

aim of this was to take the cosumers into confidence , to bring discipline and scientific methods in water distribution and management. M.V calculated the water flowing , the area under irrigation of each canal along with the crops grown. M.V guaranteed the farmers to supply the required water based on calculations. After deciding the quantity of water on scientific basis M.V gave the option of managing the distribution of canal water to the farmers. The farmers escaped from this responsibility.

As a result of this scientific approach ' Memorandum On The Irrigation Works In The Bombay Presidency Excluding Sindh' came out as hand book from M.V. In this book suggestions were given to bring the maximum land under irrigation with available water and the ways to implement them ' Block System of irrigation' was proposed. Indian Irrigation Commission under Sir Colin Scot Moncrief recommended to implement this new system.

To understand the Block System proposed by M.V one must understand the traditional water sharing system prevalent in Bombay region. In Bombay presidency on the foot plains of hills of western Ghats hundreds of 1-4 M high 'dams' were constructed by villagers. To share this water they had their own methods. In Dhule and Nasik regions farmers were following system called Phad or bandhara. In this system irrigated area was divided into four blocks. In any given block anybody can have any extent of their own land. In these blocks sugarcane , paddy , wheat and dry crops were grown in cyclic way. That means if in a block in first season sugarcane was grown, in second season paddy , third season wheat and in fourth season dry crops were allowed.

This 'Block System' was not practiced under large government canal irrigation system. Due to this in some areas farmers grew sugarcane , paddy and such wet crops in each and every season and became rich while others were to be contented with dry crops. M.V wanted to introduce traditional Block System on Nira canal also. The traditional block system was restricted to very small achcut area of 50-250 acres. It was not possible to bifurcate the

large Nira achcut area into four blocks . Since the achcut area was very large the water was not sufficient even to irrigate quarter of area with sugarcane. Therefore M.V modified traditional block system to suit the requirements (5,25,26) [11]

The main features of Block System proposed by M.V were as follows :

(1) Recognizing the blocks in achcut area. Restricting the sugarcane area in each block and supplying supplementary water to food crops and other dry crops. Determining the wet and dry crop water requirement in each block.

(2) Entering into agreement with farmers for a period of 5-6 years to supply predetermined quantity of water to each block at fixed rate. [12]

(3) Curbing the bribery at lower levels by fixing the quantity of water in each canal.

[11] Many attempts were made and engineering methods were implemented in European countries to contraol the wastage of water in irrigation canals by pre determining the water required by each crop. Baird Smith who visited Italy to gain higher knowledge in irrigation system had developed a control devise/system called ' Module Magistale' in 1855 to control flow in canal. When this system was silted , farmers who doubted its function from the beginning destroyed it. After this in 1860 and 1874 three year agreemet was made with farmers to supply irrigation water. The water supplied for irrigation was taxed but there was no control on the quantity of water utilized. While some farmers wasted the water others used it judicialy. Controlled –taxed and uncontrolled-taxed both systems of distributions were failures. Combining these two systems and traditional Bhandhara system inMaharashtra M.V proposed his 'Block system of irrigation'.

[12] After harvesting sugarcane farmers were watering the stubble for next crop. This continued for 3-4 rotations. New to new sugarcane cycle was roughly 5-6 years. Keeping this in mind M.V prposed the agreement for water supply for 5 year term.

(4) Controlling misuse and overuse of water by fixing the tax on quantity of water used rather than the type of crop and area of cultivation.

The Block System of Irrigation envisaged on the above four principles had the following features.

(1) Dividing achcut area under each distributary into 3-4 blocks and restricting sugarcane to 1/3 of that area. Allowing dry crops in remaining 2/3 area with rotation of dry and wet crops in cyclic order. In each block supplying water for sugarcane areas for 12 months and 8 months for other areas. Demarking the area into 1.5 acre units. In this 0.5 acre is for sugarcane and other 1 acre for irrigated dry crops.

(2) Under the above conditions each farmer entered into the agreement with government. This agreement was part of total agreement of all such farmers. In turn government assured fixed quantity of water in fixed time period to the farmers.

(3) In each block whatever be the nature of crop and area of crop government supplied water as per (1).

Initially there were indications that Block System was successful and yielded its results. Due to supply of fixed quantity of water the anxiety of sugarcane growers was over as they got promised water. As dry crops received their share of water with assured yield the price of food grains were stabilized. Since the water to sugarcane was assured the carts , vehicles increased to transport the material along with supporting livestock. Farmers started to grow jowar as demand in animal fodder increased. This brought positive effects socially and economically. The responsibility on engineers was greatly reduced since the quantity of water to be released was pre fixed.

But as the time elapsed the defects in Block System started to come out one after the other. There were many practical difficulties in implementation which resulted in failure of Block

System within short period. The main draw backs and defects of the system are enumerated below:

(1) The nature of ownership of land in bandhara system which was inspirational to block system was very different. The land under bandhara system was limited and the number of farmers involved in it were very small , within hand count. There farmers interacted themselves and shared the water. When the achcut area was very large such participation was not easy and practical.

(2) Engineers were deciding the requirement of water based on each crop by their own established methods. But these calculations were deviated at field level. Therefore there was great difference between the water supplied and actual water required. The wet and dry areas in a block were scattered. The water consumed for 100 hectares of wet area in one location was different from the same extent of area in other location. Therefore engineers considered the lowest among these as the correct quantity and any additional water beyond this as being wasted. Befor coming to this conclusion they did not consider the nature of soil , weather effects , rains , variations in cultivation etc., Hence the quantity of water fixed by M.V had many anomalies within it. (41)

(3) In traditional bandhara system the achcut was divided into 4 blocks. There was no restriction to the extent of land holding for growing particular crop when their turn came. Therefore when their turn came the farmers with large holdings grew sugarcane , paddy and other commercial crops and became rich. From general outlook the bandhara system seemed to be based on equity but actually it was unequal system based on the land holdings.

In M.V's block system in each block 1/3 of irrigated area was identified as wet area. But the land of all farmers was not in the wet area. Therefore the farmer who had land in wet area after growing wet crop in one season was to shift to dry area to enable the farmer from dry area to move in to his land for wet crop. Otherwise each farmer in the village have to have land in wet area. Both of these were impossible to implement. The farmers in wet

area did not agree to move to dry area after their chance expired. This brought severe drawbacks to M.V's block system and was forced to make changes in it. In future days other engineers modified M.V's system and Instead of identifying 1/3 of land in a block as wet area they recognized 1/3 part in each farmers land as wet area. By this the unequal sharing which was inherent in bandhara system due to land holdings was once again brought into practice.

(4) Because of geographical , ownership complicacies and nature of crops it was impossible to identify different blocks. In same block 1/3 wet and 2/3 dry area were scattered which made identification and water management impossible task.

(5) Since the irrigated and un-irrigated lands as well as wet and dry areas within a irrigated block were scattered it was very easy to convert un-irrigated areas into irrigated areas and extend dry areas into wet areas within a block. Hence in short time the farmers in dry area started to cultivate wet crops and the farmers outside the block also started to use canal water. Due to this there was no match between the quantity of water determined by engineers and actual water consumed. Engineers strived hard to control this and discipline the farmers , but ultimately they failed miserably.

(6) The farmers who became rich by growing sugarcane on upper reaches took lease of the land within a block from other farmers and extended sugarcane cultivation. In due course of time they did not care or fear anybody in extending this area beyond the block.

(7) During years of good rain 2/3 of block area did not required water. Therefore the farmers did not pay water taxes as it was fixed on the quantity of water used and not on type and area of crop. In such a situation the farmers in 1/3 area were very eager to pay taxes and take additional water and extended wet area. Even during rainfall deficiency they cultivated sugarcane in extended area

(8) The powerful farmers of upper reaches were demanding the water exceeding their quota and period through pressure tactics. The lower grade workers were bribed profusely for this to let water into canals unofficially.

(9) Sugarcane area extended beyond limits under pressure tactics. Due to excessive use of water lands were water logged and lost their fertility making it unfit to agriculture. [13]

To distribute irrigation water to fields different methods such as Warabandi/Osarbandi (Punjab, Haryana, Rajasthana , Uttara Pradesh) , Sejapali (Maharashtra , Gujarath) and Localisation (West Bengala , Orissa, Jammu & Kashmir, Karnataka , Andhrapradesha , Telangana) were in practice from many centuries. These methods and combination of these methods are prevailing in Indian states Including Karnataka. (26). Warabandi was the system introduced by British to provide supplementary water to food crops and reduce the severity of famine. In this system the social justice has upper hand over commercial profits. Aim of this system is to provide water to the maximum number of people rather than to sell it at the maximum price. In Sejapal system farmer decides the quantity of water required and applies to the government for supply. After totaling all such demands from farmers , comparing it with the actual quantity of water available engineers decide the quantity of water which can be allotted to each farmer. This is not rationing system like warabandi but in one way controls the unrestricted demand of water from the farmer. In localization system the type of crop to be grown in each canal system is restricted. Therefore the canals are categorized as sugarcane , paddy canals , cotton , millet, ground nut canals etc., In this system paddy or sugar cane cannot be grown in achcut of canal which allows only millets. Even

[13] On 20/12/1901 members of Irrigation Commission of India questioned M.V whether the proposed Block irrigation system really practical to implement. 'It may possible ' was the answer from M.V. All the doubts raised by committee members became real after the system was implemented.

though M.V's block system seems to be synthesis of warabandi and Sejapal system it is not true. Because the Block System proposed by M.V was based on nonexistent ideal conditions, assumptions. The fact that in Nira canal achcut the blocks as visioned by M.V were never identified and never implemented as proposed is itself a mark of grand failure of this system.

M.V was very fond of his failed Block System of irrigation. Even though It was a miserable failure on Nira canal M.V never tried to know the reasons or to improve it. On 1/7/1913 Block Irrigation System was implemented in Marikanive project. While speaking in Mysore Engineer's Association regarding the project M.V said that to make full use of water in the reservoir high level canal was proposed. That is completed and water was released for irrigation. The block system has been explained to the farmers in detail for free and full utilization of water. The farmers have principally agreed for that. The higher income can be expected by allowing cultivation of sugarcane in achcut area of this canal. If the proposed irrigation area is reduced by encouraging commercial crops like sugarcane then 1/10 to 1/15 of profit from such crops can be collected as water tax. After some days he had informed that the block system introduced in Marikanive project was satisfactory , the demand for water and irrigated area had increased , The outsiders are settling in achcut area. But within next two years the block system was a disastrous failure.

Instead of recognizing the reasons for this failure some of M.V's admirers have felt that the non-cooperation from engineers caused it. But this not true. In Nira achcut area M.V had full support of British government. In Marikanive project he was the chief engineer of the project and Maharaja gave full freedom for execution. In such a situation the real reasons shall be sought. It is not fair to take all admiration for successful projects and showing fingers to others when failed. Even after 30 years of KRS project completion it was not able to introduce Block Irrigation System for achcut under Visvesvaraya canal due to practical reasons.

It has been projected that since Indian Irrigation Commission under Colin Scott Moncrieff allowed implementation of Block System as proposed by M.V without modification it is most suitable system. Colin Scot-Moncrieff had felt that the farmers are wasting canal water on east delta region of Egypt. M.V had recognized similar situation on Nira & Mutha canals and proposed block system. To Colin Scot Moncrieff this was one of the possible solutions. He also thought that it is enough to release the calculated quantity of water into the canal through which maximum returns would come.

Construction of dams and canals are direct engineering problems having definite technical solutions. In distribution of canal water non-technical aspects of society , culture and history are interwoven. For such problems there will be no single solution but probable many solutions ; even any one of these solutions may not solve the issue. M.V has suggested a solution to such a problem. The outcome it was to be known by implementing it only. Therefore as a part of such an attempt green signals were shown to Block Irrigation System. The merits and demerits of it emerged accordingly. To solve the problems faced in water distribution engineers have proposed many systems based on their experience and technical knowledge. None of these is complete and perfect. Every system has its own merits and demerits in implementation. The fact that Block Irrigation System is not adopted anywhere in India fingers to the fact that it was a failed system.

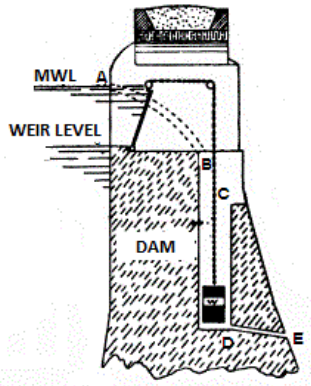
3.3 Automatic Gates

The design and patent of automatic flood gates is considered as the greatest achievement of M.V. The history of concept , design and installation of these gates is very curious. Therefore the role of M.V in this is seen in detail in the following pages.

3.3.1 Original Concept And Design

Gates are provided in the dams to control the flow, water level and to store the water above weir level when flood recedes. Such

gates have to be lifted/operated manually or with the help of mechanical equipment. In large dams such gates can be 50-100 in number. To lift large number of gates much human or mechanical effort and time is required. It may not be possible to lift these gates during flash floods. In such situations the gates which store water up to a certain level over the weir and open themselves automatically allowing excess water to flow out when the water crosses fixed level are most suitable. Automatic gates irrespective of human intervention and flood time open up , allow excess water to flow out and close when the water in the reservoir reaches a certain level. Such automatic gates were installed over dams throughout the world. Automatic gates had their own advantages and disadvantages.



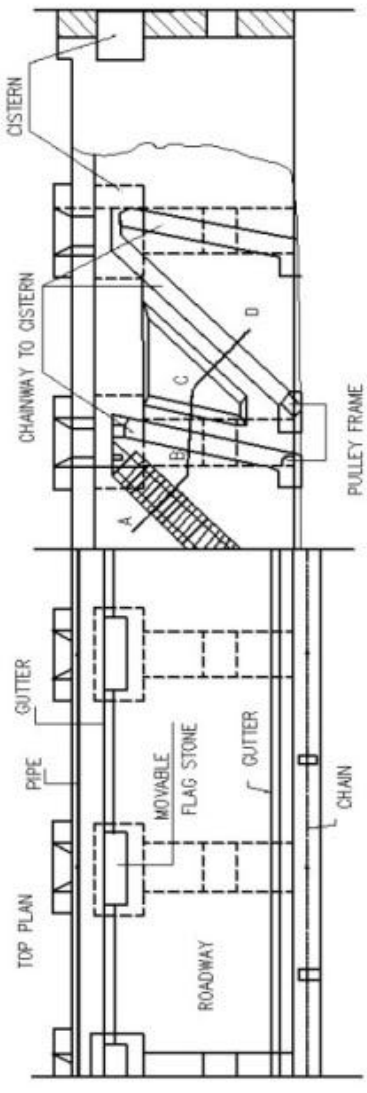
WHITING AUTOMATIC GATE

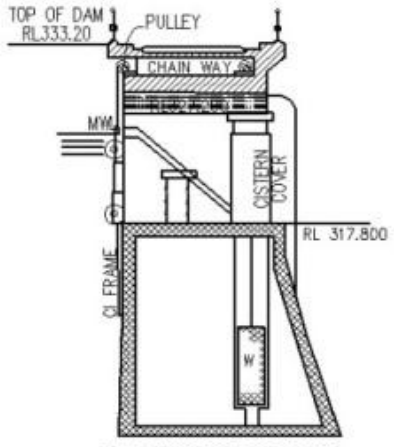
Whiting who was the chief engineer of Bhatghar dam had designed the automatic gates which could be installed over the weir of dams. This automatic gate proposed by Whiting was hinged at bottom and connected to a chain at top. In turn the chain was connected to a balancing weight W placed in the well-formed within the dam body. A vent AB was provided in the dam body which connected upstream face of dam to the well. The exit vent DE which was smaller than AB was also provided to let out the water which fell in to the well. When water level crossed certain limit the water from reservoir flowed to the well through vent AB and flowed out through vent DE. But the quantity of water entering through vent AB (inlet water) was more than that flowed out of vent DE (outlet water) . Therefore the water level in the well increased. Due to buoyancy effect the weight W was raised slackening the chain and lowering the gate through rotation at bottom. When the water level in the reservoir dipped below

certain level the water flowing into the well through vent AB was reduced and the water in the well was gradually drained out through vent DE ultimately emptying the well. Due to this buoyancy effect was lost and the weight W brought the gate to original closing condition. Even though the concept of the gates designed by Whiting was correct there were some practical problems in it. When the water level in the reservoir went below certain level the gates were not closing immediately but slowly. Due to this water was lost and instead of retaining water to full height of gate only 600 mm height of water was retained above weir level. (Fig : Whiting Gate)

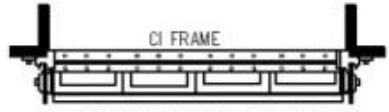
E.K Reinold improved the action of Whiting gate and obtained the patent for them. These gates were installed over weir of Bhatghar dam. Bhatghar dam had 103 vents of 3.05 M width for flood discharge. Out of these 88 vents were provided with E.K Reinold patented gates. From 1892 these gates worked successfully. [14] (Fig: E.K Reinold Gate)

[14] The original project report of Bhatghar dam inculded the proposal to generate electricity. For this pipes were provide at the bottom of the body of the dam to convey water to power station. Poona region received water through left bank Nira canal of Bhatghar dam. There was immense pressure to supply water to Solapura area which was reeling under repetitive faminines. Proposals were made to raise the height of Bhatghar dam to increase storage capacity. Since suitable foundation was not available on immediate downsteam face of Bhatghar dam , it was sdecided to build new dam on 100 M upstream of existing dam which had suitable rock for foundation. The new dam constructed between 1913-1928 was named as 'Llyod Dam'. The new dam was designed by executive engineer C.B Poole. After completion of new dam old Bhatghar dam became defunct. During construction special arrangements were made to divert the water collected in the reservoir of the old dam. The space between new and old dam is always filled with water. Power required for constrction of Llyod dam was obtained from that generated by Bhatghar dam

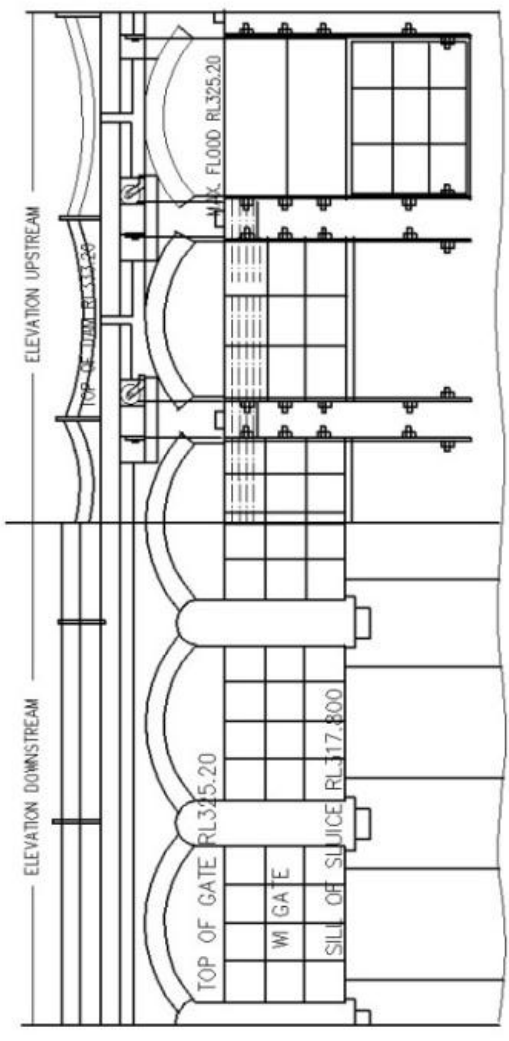




CROSS SECTION



SECTIONAL PLAN



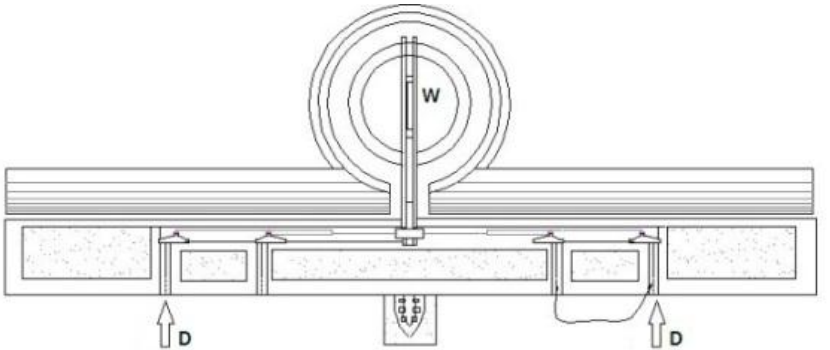
PLAN SHOWING CHAIN WAY & SITE OF PULLEY
AUTOMATIC WASTE WEIR GATES OF THE BHATGARH DAM((LAKE WHITING)

E.K Reinold gates were held with chains at top. These chains moved over pulleys and were connected to the weight W in the well. The weight of gates and weight W balanced each other and kept the

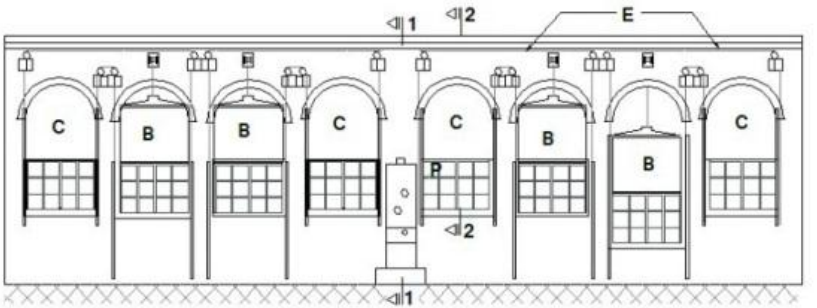
gate in vent closed position. Similar to Whiting concept inlet vent AB and outlet vent CD were provided. When inlet water is more than outlet water due to buoyancy effect the weight W is raised and in turn the gates were lowered letting out the water above certain level. When water receded below this level the well was emptied bringing down the weight W to original position and closing the vents. Gate and weight W had finer adjustment to exceed the frictional resistance between gate wheels and rails. To enable smooth movement of wheels rails were tapered. Due to this a small gap remained between dam inner face and dam gate. Through this gap small quantity of water leaked out. Each Reinold gate installed on Bhatghar dam weighed 2.9 T while the weight W with in filled sand in it weighed 4.21 T in air and replaced 3.3 T of water. Under buoyant condition gate lost 0.985 T and was lighter than gate by 1.91 T. The arrangements to change the weight W as per requirements were also made. During maximum flood condition Reinold gates moved down by 2.44 M from weir top level. Thus they retained 2.44 M of water above weir level. (2:166-168, 13:196-201)

Khadakawasla dam was built to supply drinking water to Poona as well as for irrigation. Many times it was not possible to meet both these demands. Some attempts were made to retain water above weir level. It was found that by raising reservoir level by 1.22 M it was possible to store additional 1.294 TMC of water and this was 50 % of the capacity of the reservoir. Therefore in 1884 proposals were made for this. The steel columns were raised over the weir and 1.22 M high wooden planks were fixed between them. During design the probable maximum flood at Khadakawasla dam was calculated as 1750 Cumes and weir was designed to discharge 2128 Cumecs – 20 % higher than maximum flood. During flood times it was very dangerous to fix up the wooden planks across the embedded steel columns. In 1900 1.12 M water flowed over the 1.22 M high wooden plank gates and the workers were unable to remove the planks immediately. Therefore like Bhatghar dam it was decided to install E.K Reinold gates. (13:198-199)

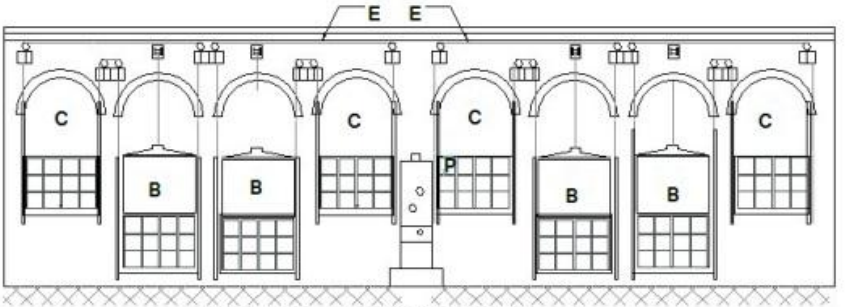
In 1899 M.V was executive engineer of Mutha canal of Khadakawasla. From here onwards M.V started to appear as the inventor of Automatic gates. Even though the gates first proposed by Whiting , improved by E.K Reinold were working perfectly in Bhatghar dam it was not possible to install them on Khadakawasla dam. In Bhatghar dam necessary arrangements were made during construction stage to install E,K Reinold gates. But Khadakawasla was not built for such installation. Therefore M.V came forward to suitably modify and install the Reinold gates on Khadakawasla dam. On 2/1/1902 M.V filed an appllication to the Secretary , under Invention and Design Act of 1888 for for obtaining patent for Modified Reinold gates. This was published as 'No. 102 of 1901 ' in 'Government Of India –Department Of Revenue And Agriculture – Gazette Of India-Part-2- Invention & Design. The patent was sought under the heading ' Improving The Automatic Action Of Sluice Gates Of waste Weirs Or dams Of Reservoirs' (Fig: MV – Automatic gates)



PLAN SHOWING ARRANGEMENT OF CHAIN

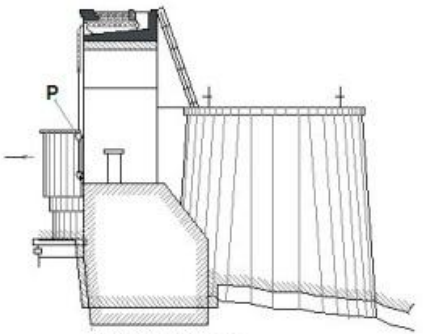


ELEVATION GATE OPENING

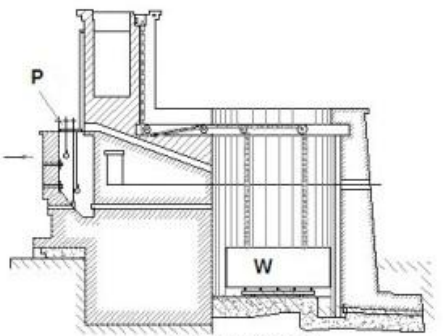


ONE GROUP OF AUTOMATIC ON
THE WASTE WEIR OF LAKE FIFE.

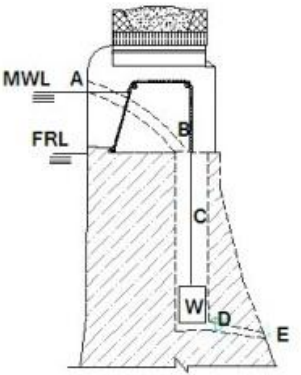
ELEVATION - GATE CLOSED



SECTION 1-1



SECTION 2-2



WHITING'S SELF-ACTING
WASTE WEIR GATE

Conceptually & technically there is no difference between Reinold gate and M.V gate. In Reinold scheme for each gate there were two wells on either side of the gates. These wells had weights W to automatically control the gates. Instead of this M.V grouped 8 gates and provided single weight W in a single well for them. The weight of these gates and weight were balanced. During floods out of 8 gates 4 gates moved up and 4 gates moved down to open the flood vents. By slightly changing the arrangements it was possible to make all the gates to move up or down simultaneously. Heavy gates weighed 5.8 to 6.1 T and light gates weighed 2.24 T. The heavy and light gates moved by same distance. The heavy gates were connected to weight suspended in the 20-22 Cu.M capacity well through chains. Since the weight W comprised of closed cylinder it was possible to change its weight by filling or removing sand in it.

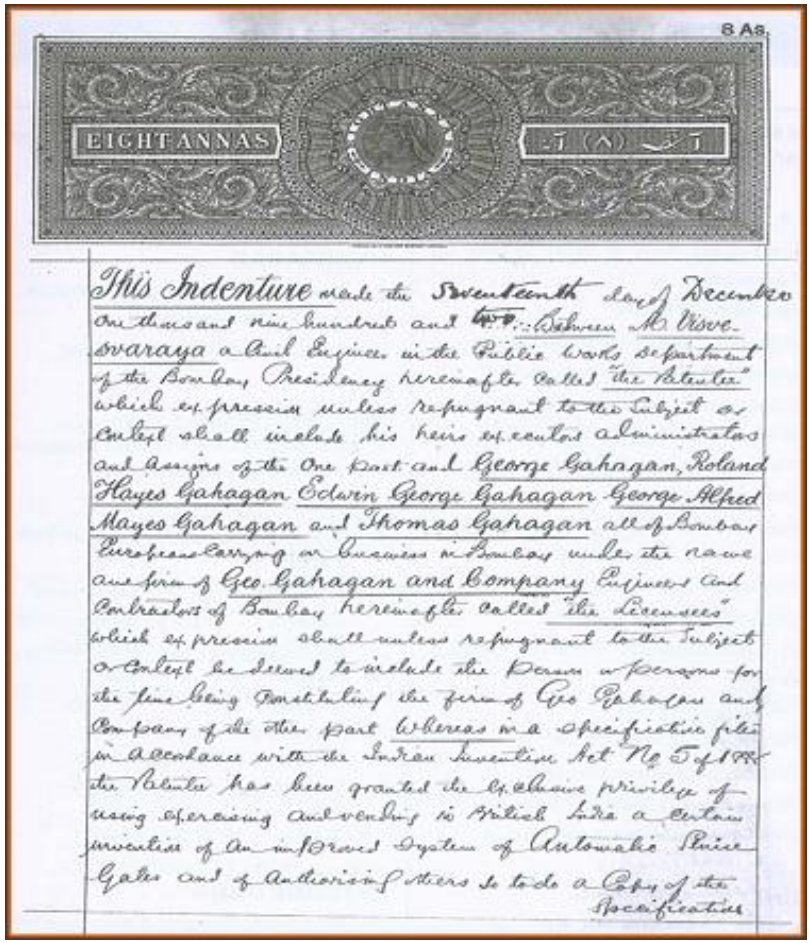
A small feed channel has been constructed on the upstream face of the dam at weir level. The water level in this channel is 150 MM below the maximum water level in the reservoir. An inlet pipe provided at 'P' connects the channel and the well. At the bottom of the well oulet pipe is provided. When there is no water in the well , the chain connecting the gates and weight in the well is in tightened condition. When water in the reservoir crosses certain level, water starts to flow into the well through pipe at 'P'. As well is filled up with water the weight W loses weight due to buouancy and starts to move up slackening the chain. Then the heavy gates move down below the weir level and simultaneously lighter gates move up to the vent top level. When there is no supply of water from 'P' the collected water in the well drains out emptying it. With no buoyancy effects the weight W regains its original weight , moves down , tightens the chains and closes the vents by moving heavier and lighter gates up and down. By providing valves at different levels in feed channel the water level in the reservoir can be fixed at any required level.

M.V got patent for the improved gates. After obtaining the clearance to install them over Khadakawasla dam M.V entered into

agreement with M/S Geo Gahagan and Company to manufacture gates. In 1901-03 duration these gates were installed on Khadakawasla dam. M.V has reported that even though he had patent for the gates he did not take any royalty as the installation of gates was done under his in charge. On Khadakawasla dam 8x11=88 M.V gates were installed. The cost of gates was 3 lakh Rs and the installation and civil works amounted to 2 lakh Rs. Afterwards it came to be known that when the valves in the feed channel are controlled manually 7 minutes were required to open and 8 minutes to close the gates. To control all valves a person required 20 minutes. Similar gates were installed on Tigra dam near Gwalior in Madhya Pradesh and KRS in Mysore state. M.V had also recorded that even after 45 years of installation when he visited Khadakawasla the gates were in full action. [15]

This indenture made – Seventeenth day of December one thousand nine hundred and two between M.Visvesvaraya a civil engineer in the public works department of the Bombay presidency hereinafter called "the patentee" which expression unless repugnanat to the subject or context shall include his heirs , extended administrators and assigns of the one part and George Gahagan , Roland Hayes Gahagan , Edwin George Gahagan , George Meyers Alfred Gahagan all of Bomabay Europeans carrying on business in Bombay under the name & firm of Geo Gahagan & Co., hereinafter called 'the licensee' which expression shall unless repugnanat to the subject or context & be deemed to include the person or persons for the time being constituting the firm of Geo Gahagan and Co., of the other part whereas in a specification filed in accordance with the Indian Invention Act No.5 of 1888 the Patent has been granted to exclusive principle of using excercising and vending to British India a certain inventions of an Improved system of automatic sluice gates and of authorizing – to do a copy of the specifications

[15] Tigra dam which was completed in 1909 collapsed in 1917 due to uplift forces in the foundation. This dam was rebuilt in 1927 . The flood water was controlled through 16 Duncan Type and 64 M.V automatic gates provided in and over the body.


8 As.
EIGHT ANNAS
This Indenture made the Seventeenth day of December one thousand nine hundred and two Between M. Visvesvaraya a Civil Engineer in the Public Works Department of the Bombay Presidency hereinafter called "the Patentee" which expression unless repugnant to the subject or context shall include his heirs executors administrators and assigns of the One part and George Gahagan, Roland Hayes Gahagan Edwin George Gahagan George Alfred Mayes Gahagan and Thomas Gahagan all of Bombay Europeans carrying on business in Bombay under the name and firm of Geo. Gahagan and Company Engineers and Contractors of Bombay hereinafter called "the Licensees" which expression shall unless repugnant to the subject or context be deemed to include the person or persons for the time being constituting the firm of Geo Gahagan and Company of the other part Whereas in a Specification filed in accordance with the Indian Inventions Act No 5 of 1888 the Patentee has been granted the exclusive privilege of using exercising and vending in British India a certain invention of An improved System of Automatic Sluice Gates and of Apparatus for to do a Copy of the Specification

Fife who designed and constructed Khadakawasla dam knew that his methods were not correct and they did not follow prevailing engineering standards. Earthen bund was constructed on down stream of the dam to prevent from sliding. The patented E.K Reinold gates were first installed on Bhatghar dam which was designed and constructed as per engineering practices of the day. M.V was installing the gates on a dam which was not built as per standards and whose safety was in doubt. Due to raising the storage height by installing gates, the hydrostatic forces on dam would increase and there were possibilities of compromises on the

safety of the dam. M.V does not provide even single technical fact regarding issues such as whether any discussion was taken to restrengthen or not to strengthen the dam , who took final decisions and on what was basis for that etc., Thus M.V is an expert telling 'technical stories' without providing any details.

The original concept of Automatic Gates does not belong to M.V. He appears in third stage of such concept and progress .(Whiting-Reinold-M.V). In contemporary engineering literature these gates were never considered as engineering marvel but as one of the many engineering solutions. In 1903 , Herbert M. Wilson in 'The Irrigation in India' and in 1905 Robert Burton Berkley in ' The Irrigation Works Of India' record these gates as one of the many such concepts and attempts. No contemporary technical literature speak much about these gates. One or two references which spoke about these gates considered them as normal concepts. After M.V occupying the post of Chief engineer and consequently Diwan of Mysore princely state one particular 'class' started to glorify each and every engineering work of M.V as a marvel. Thus wide fanfare was made around Automatic Gates of M.V . The name of other engineers who pioneered many such gates was never spelled.[16]

Except the fact that gates opened and closed automatically they are different from other flood control gates. Anything created by humans has its own merits and demerits. If anything perfect is achieved there will be nothing for humans to do further. Were the M.V gates so perfect without any conceptual and practical defects ? Only the users of these gates can answer this. Nobody has neither recorded nor studied the maintainance , repair and performance of

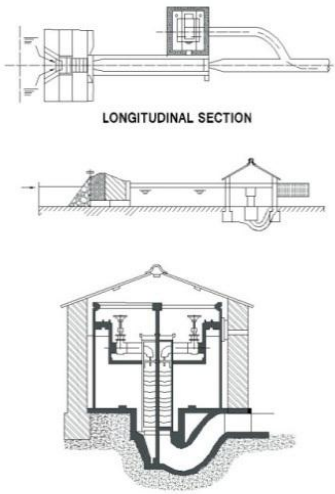
[16] Earnest Oscar Mavson , Executive Engineer and Undr secretary of Public works Department of Bomaby presidency had patent for design and construction of atutomatic floods which can be installed on dam weir in 1903. But he did not receive any propaganda as in case of M.V

these gates. In praise of M.V these real issues are shyed away from public view.

Without having direct experience of the operation of these gates butfrom concept and designs some observations can be made. E.K Reinold gates were independent but M.V gates act in group of 4 or 8. If any technical or performance problem occurs in any one of the gates all other gates will be inoperable. If any gate is taken out for repair, maintenance then equivalent weight has to be placed in place of it. This has many practical problems. Therefore if engineers who use these gates record the performance of these gates then only their objective assessment can be made.

Regarding these gates the real facts are buried silently. These famous 'Automatic gates' of M.V in KRS dam never operated as designed from the day of installation. It is better to declare them as failed grand show pieces of engineering or seal them in position as inoperable.

3.4 Canal Regulator



Successful implementation of Block system irrigation depends on supply of the predetermined quantity of water into the canal. To achieve this many engineers like Gibbs, Crump etc., proposed various control devices long back. A few of them were implemented. M.V did propose one such control system and structure. This is very similar to concept of automatic gate. This control module was first discussed in Irrigation Conference that was held in Shimla in 1904 along with automatic gate.

In this controller the distributor is connected with a chamber. The water level in the chamber and canal are same. In chamber a floating barrel has been placed. The water in chamber enters the barrel through a valve. The lower side of barrel is connected to the canal lower portion through a hose pipe. As per the level in the chamber water flows into the barrel. If the water level in the chamber crosses a certain level accordingly hose pipe shortens, moves down and brings back the water to original level. Therefore only fixed quantity of water flows through the canal. We do not know whether such controllers were erected on Nira canal or on Marikanive canal. [17]

3.5 In Design Of Dams

3.5.1 Osman Sagar And Himayat Sagar Dams

By identifying M.V with Kannambadi dam (KRS) the myth has been propagated throughout Karnataka that M.V is such a tall figure in dam design that nobody can go near him. In this background let us proceed to know the experience and expertancy of M.V in design of dams along with the methods adopted , the formulae , expressions used by him in designing of dams.

If one glance through the professional life of M.V it is very clear that until 1909 when he was called for to provide solutions to Hyderabad flooding he never had any experience in designing and construction of a dam. In Bombay presidency when he was serving as Assistant engineer, executive engineer , superintending engineer he was engaged design , execution and in-charge of in canal operation , canal maintenance , water distribution , urban water supply and sewage disposal. He was never in a team of dam design. Khadakawasla reservoir (Fife Reservoir) was constructed before M.V joined the services. When Khadakawasla dam construction

[17] In 1870 a controller which worked on similar principles was installed in Gorbals Water Works project near Glasgow.

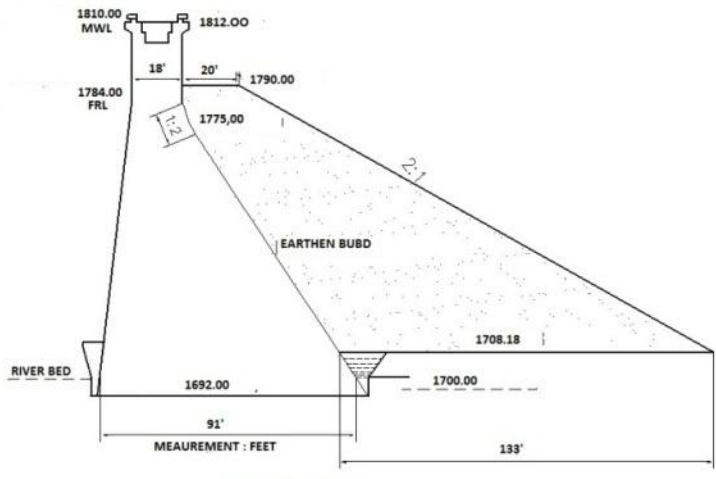
was started in 1870, M.V was a village boy in shorts in Muddenahalli. Bhatghar , Tansa dams were designed and executed by British engineers. Due to efforts of Fife the principles of design and construction of dams , their records were available in government irrigation department. There is no doubt that M.V who was in the same department had seen all these.

The first big dam designed by M.V was Osman Sagar dam across Musi river near Hyderabad. (1912-1920). In line with this design Nawab Ali Nawaz Jung designed and constructed Himayat sagar dam across river Easi (`1919-1926) and also Wira and Kaddam dams. The construction of Osman Sagar dam was done under the leadership of C.T Dalal. Osman sagar dam help us to understand the 'expeRtancy' of M.V in design of high dams.

(1) The Construction of Osman Sagar dam which is 34.16 M high from river bed and maximum of 36.6 M high from founding level was started in 1912. The Himayat Sagar dam which was started in 1919 is 27.785 M from river bed level and 32.05 M from founding level. Both these dams are recorded as being designed as self-supporting Gravity dams which are safe in sliding and overturning . But large earthen bund is provided on the downstream of these dams.

'No. 48 : Data Of High dams In India-1950' published by Central Irrigation Department , Government Of India records that M.V designed Osman Sagar dam as Gravity Dam. It also provides a foot note that to achieve higher safety against sliding earthen bund was constructed on downstream side of the dam. Some sources say that the maximum storage level of the reservoir was raised and when the design was rechecked with the revised level tensile forces were reported on the toe and to nullify them M.V introduced the earthen bund on downstream side. This statement can be shown to be false from basic dam design calculations. Data Of High Dams In India-1950 which provides full history of the dam does not give any information on the revised reservoir level. There was no instance in the contemporary world that after designing

Gravity Dam with the established methods of the time earthen bund has been provided on downstream side of the dam for additional safety against sliding. (Fig: C/S Of Osman Sagar Dam)

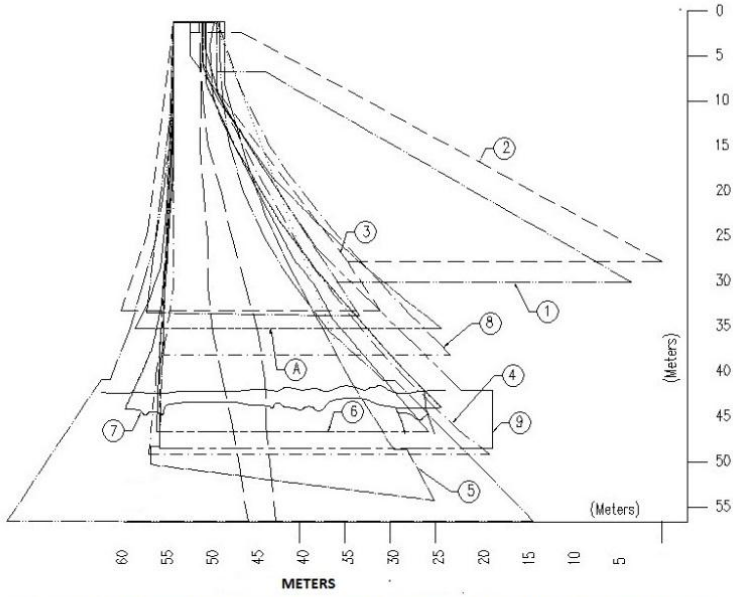


OSMAN SAGAR DAM SECTION

(2) Osman Sagar dam is 1921.5 M long. In this Non-Overflow section is 1406.05 M and length of weir to discharge flood is 515.45 M. The earthen bund has been provide for Non-Overflow section of 1406.05 M length and not for weir portion. From technical point of view there is no difference in design of Overflow and Non-Overflow sections of the dams as they are subjected to same hydrostatic forces. Also while designing the Gravity Dam it is standard practice to consider unit width of 1.0 M. Technically it is wrong to separate over flow & non-overflow sections and providing earthen bund to non-overflow section only.

(3) When Gravity Dam is designed it is not necessary to strengthen it further. This is because after considering all possible loads, load

combinations only the dam will be designed with suitable safety against overturning and sliding. A designer may consider additional forces with proper backup while designing the dam but once such forces are considered there is no necessity to strengthen the dam designed by himself. The designer has every right to consider additional , acceptable safety factors before taking up the design. Therefore the question arises that why did M.V not included additional safety factors during design stage itself. (Fig : Comparision Of C/S Of Various Dams)



(1) OSMAN SAGAR (2) HIMAYAT SAGAR (3) BHATGHAR (4) CHAMARAJASAGARA (TIPPAGONDANAHALLI) (5) LYODS (6) KANNAMBADI (KRISHNARAJA SAGARA) (7) MARIKANIVE (VANIVILASA SAGARA) (8) TANSA (9) KHADAKAVASALA (A) BIUVIER

COMPARISION OF VARIOUS DAM CROSS SECTIONS

After designing Osman Sagar dam as Gravity Dam there can be no technical justifications for M.V to provide huge earthen bund on downstream side. The earthen bund provided by M.V is so large that instead of constructing masonry dam he would have adopted earthen bund itself. The additional earthen bund is technically not required and does not have support of any established engineering principles. During construction stage other engineers clearly raised objection to the earthen bund and argued that it has no role except increasing the cost of the project. It is known from other obscure sources that M.V defended himself by saying that earthen bund has been provided in Aswan dam. The technical controversy of the earthen bund went up to Michel Nethersole , Chief Engineer, Irrigation Department of British Government. There is some vague information that after seeing the calculations Nethersole approved M.V approach. Whatever may be the fact the approval of Nethersole cannot protect M.V from erroneous designs.

(4) There is no relation between strengthening of Aswan dam and providing earthen bund on downstream side by M.V. Nile is one of the biggest rivers in the world. Since from ancient times is was a boon by providing water for irrigation , drinking and a bane by devastating floods. Proposals to control flood and to store 2.496 B.C.M water (88 TMC) for irrigation by construction of a dam were on anvil. Such a reservoir if constructed was submerging world famous Phile and Abu Simbel temples constructed in B.C.E 1700. Public pressure mounted to lower the dam height to save these temples. In this background revised Aswan dam project started in 1898 and when completed in 1902 rose to a height of 36.6 M with the reservoir capacity of 0.98 B.C.M (34.54 T.M.C). The force of water which was let through the vents in the dam body during heavy floods dislodged the rock formation of river immediately on downstream of the dam. To control this in 1905-06 additional masonry platform was constructed on downstream side of the dam.

By 1905 there was great demand for water from Aswan dam and pressure to increase the reservoir capacity mounted. To study the

feasibility of these services of Benjamin Baker who was one of the member of technical committee of the original project was engaged as consulting civil engineer. After searching alternate site and solutions it was concluded that raising the dam was the only way to increase the capacity. Ultimately It was finalized to raise the dam by 7.0M and storage height by 5.0 M to achieve the target storage capacity of 2.198 B.C.M (77.5 TMC) . As a part of this the dam downstream side was strengthened by widening by adding masonry and in second stage the height was raised. Old and new masonry were bonded together with steel rods.

In Aswan dam for additional safety earthen bund was not provided. Old and new both were stone masonry structures. Therefore , if we once again look back at the huge earthen bund provided to Osman sagar dam it will be very clear that M.V was afraid of the consequences and was not confident of his designs. This can be demonstrated by the following simple calculations of sliding of various dams.

Sliding Safety Calculations

Dam	Cross Section Area (Sq.M)	Density (T/Cu.M)	Weight of Dam(T)	Hydrostatic Thrust (T)	Factor of Safety Against Sliding
Khadakawasla	523.64	2.42	1267.20	406.79	1.86 (2.18)
Tansa	557.42	2.40	1337.80	726.75	1.11 (1.29)
Periyar	1163.51	2.30	2676.0	1146.48	1.40 (1.64)
Mari Kanive	843.62	2.40	2024.69	860.29	1.41 (1.65)
Osman Sagar	509.96	2.25	1147.42	562.80	1.22 (1.43)
Himayat sagar	500.625	2.25	1126.40	352.00	1.92 (2.24)
Kannambadi (KRS)	733.55	2.33	1709.18	715.17	1.43 (1.67)
Mettur	1954.58	2.40	4691.00	1507.00	1.86 (2.17)
Tippagondana Halli	970.36	2.32	2251.00	697.97	1.93 (2.25)
Tokarawadi	1251.52	2.56	3203.00	1679.10	1.14 (1.34)
Lyod	872.71	2.56	2234.15	1312.72	1.02 (1.19)
Mulshi	710.00	2.38	1689.94	885.71	1.14 (1.34)
Radha Nagara	712.14	2.25	1602.31	738.43	1.30 (1.52)
Wilson	2576.80	2.40	6184.30	3390.76	1.09 (1.28)
Kakoto	446.98	2.24	1001.24	547.56	1.097 (1.28)
Tamraparni	1513.00	2.40	3631.52	1408.21	1.54 (1.80)

Coefficient of Friction Cf = 0.6 and 0.7

(A) Osman Sagar dam – per M length

Weight of dam = 1147.41 T
The weight of earth on dam = 488 T
Hydrostatic Force = 562.80 T

(1) Without considering the earthen bund

Safety against sliding = 1147.41 x 0.6 /562.8 =1.22 for Cf=0.6 & 1147.41x0.7/562.8=1.43 for Cf=0.7

(2) Considering the earthen bund

Safety against sliding = (1147.41=562.8)x 0.6 /562.8 =1.82 for Cf=0.6 & (1147.41+562.8) x0.7/562.8=1.49 for Cf=0.7

(5) The factor of safety of various dams constructed during same period against sliding are tabulated in the Table. This factor was varying between 1.1 to 2. The engineers preferred factor of safety of 1.5 against sliding. If the factor of safety against sliding is increased to 1.5 for Osman Sagar dam then

(a) Increase in cross sectional area of dam = (1407.00-1147.41)=259.59 Sq. M i.e. 22.62 % for Cf=0.6

(b) Increase in cross sectional area of dam = (1206.00-1147.41)=58.59 Sq. M i.e. 5.10 % for Cf=0.7

Instead of following correct engineering principles M.V constructed earthen bund on downstream face of the dam. The additional cross sectional area of this earthen bund is 114.17 % (=582.26/509.96) of the masonry dam.

Himayat Sagar and Wira dam designs were influenced by M.V. Even though the factor of safety against sliding was more than 1.5 for these dams earthen bund was constructed on downstream of

dam unnecessarily. In case of Kannambadi dam (KRS) M.V has achieved the required factor of safety against sliding and over turning as Gravity Dam without providing any additional earthen bund on the downstream face of the dam. Therefore it can be concluded that while designing Osman Sagar dam M.V was inexperienced in design of dams and he was not confident of his own designs.

(6) M.V was using Molesworth , Unwin or M.Bouvier methods for design of masonry gravity dams. There were no methods available for design of gravity dams which considered earthen bund on downstream face of the dam. There is no proof that M.V developed his own method which considered earthen bund on downstream face of the dam. Before proposing such new methods one has to develop basic engineering principles for that. In contemporary technical literature of that time no such attempt has been recorded by anyone else. There was no necessity to develop such additional approach. M.V was totally wrong and technically blundered in providing earthen bund on downstream while using the gravity dam design methods which did not considered it.

(7) Technically it can be proved that the additional earthen bund provided by M.V to achieve higher safety against sliding was actually reducing the factor of safety of dam. The forces and moments in the dam will be higher for (reservoir empty + earthen bund saturated) condition than reservoir full condition. To increase safety against this condition one has either to increase the dam size or to construct one more earthen bund on upstream side also.

One can argue that since the dam is a very rigid structure the displacement in it are very small. In such condition the earth on the downstream side will be in rest condition exerting very low pressure hence it does not affect the original design made without considering the earthen bund. But the catching point is not that. After 1928 only the studies regarding rest condition of earth were studied and when M.V proposed the earthen bund there was no

knowledge about it. And also M.V was providing the bund as additional safety without any involved technical justification.

(8) Providing keys in foundation to achieve higher factor of safety against sliding was in practice and was adopted successfully in other dams. This enabled the engineer to adopt definite established principles and methods in design. Drainage galleries were not provided in Osman Sagar and Himyat Sagar dams to relieve the uplift pressures citing the reason that the foundation is on hard rock through which water does not seep. In such rocks providing keys is easy and desirable. Then why M.V did not go for such methods ? The reason for this seems to be somewhere else. The Tokaravadi and Pravara dams constructed during the same time which are double the height of Osman sagar dam with 4 times higher hydrostatic pressure does not have earthen bunds. No gravity dam in the world was provided with earthen bund as measure to achieve safety against sliding. With all this it is very clear that M.V lacked confidence in his designs.

(9) Without following any contemporary engineering design principles a few dams were constructed in Marwar and around Ajmer regions of Rajasthan. Niyaran dam with thin masonry wall on upstream side and earthen bund on downstream side was constructed before 1857. Similar dam of 12.81 M height was constructed in Akhaijitagarh. Similar dam was constructed in Ajmer in 1890 under famine works. Even tough the revolutions took place in the world in design of dams , some engineers continued to follow wrong old methods. After seeing such dams in 1905 Robert Burton Berkley wondered how did these damse standing even after breaking all known engineering principles.

The Himayat Sagar, Wira , Kaddam dams designed by Nawab Ali Nawaz Jung Bahaddur who was influenced by M.V and 543 M long Non weir portion of Tungabhadra reservoir have earthen bunds on downstream side of masonry dam similar to Osman sagar dam. Committee of Central Water commission which studied the safety of Tungabhadra dam in 2003 noted that the structural behavior of

masonry dam with earthen bund is very complicated and the interaction between masonry and soil shall be analysed with specialised computer programmes. Therefore the earthen bund provided on Osman Sagar dam was not based on engineering principles but on 'personal choices and opinions of M.V'

After construction of Khadakawasla dam doubts arose that the dam has slided due to hydrostatic thrust. As a solution to this Fife provided 18.3 M wide , 9.15 M high earthen bund on the downstream of the dam. M.V was in Kadakawasla for a long time as engineer in-charge. The concept of providing earthen bund against sliding was deeply embedded in his mind. Therefore he adopted the same in Osman sagar dam.

(10) In 1908 ' Low Ragged Mountain Dam' 20.44 M high with 17.35 M width at base was constructed to supply drinking water to Charlotteville-Alphamarle towns in USA. This was the transition time when concrete was replacing masonry in dam construction. Cyclopean concrete which used large sized boulders was the material of construction. This was designed as gravity dam following the standard methods of the day. (Bouvier/Molesworth/Rankine). By 1930 the upstream and downstream faces of the dam bulged due to seepage of water through foundation and body of the dam raising concerns over the safety of dam. As a measure of safety holes were drilled on upstream side of dam grouted with cement slurry and downstream face was provided with earthen bund to enhance safety.

The consulting engineers who studied this dam in detail in 2002-03 came to the following conclusions. (1) The dam is not safe as per the latest guidelines of dam design. (2) There is no clarity of concept in providing earthen bund on downstream face of the dam (3) Either by adding additional concrete cover to the earthen bund or by removing earth completely and providing concrete in its place required safety shall be achieved.

(11) 62.5 M high Talakalale dam constructed in Karnataka state in 1959-63 started to leak due to construction defects and the mortar

leached out. After failure of many attempts to stop the leaching of mortar and to achieve additional safety earthen bund wad constructed on downstream face of the dam. It was assumed that the soil is at rest state and does not exert any pressure on the dam. (11). The controversies on such conclusion are not yet over in engineering circles.

(12) By 1890 the civil engineering community came to the consensus that all dams shall be designed for uplift and earth quake forces. Before this these forces were not considered. Therefore engineers started to search for methods to strengthen the already constructed dams. Construction of earthen bund on downstream side was one of the solutions proposed by them. Since stone and masonry are different materials it is not possible to understand the interaction between these two under various forces from traditional methods. To understand interaction of different materials 'Finite Element Method ' was developed by 1960's. Without computer this method cannot be used. After 1980's personal computers with affordable prices came to market. Following this various studies were done to understand such interactions under earthquake. There are many discussions , disputes and controversies regarding such methods and their results. There is no relation between these modern methods and M.V providing earthen bund on Osman sagar dam.

3.5.2 Mysore Princely State & Irrigation Projects

3.5.2.1 Marikanive Project (Vanivilasa Sagara Dam)

Progressive princely states were keenly observing the fast pace of development of irrigation in areas which were under direct control of British. Queen Kempa Nanjammanni (Vani Vilasa Sannidhana) who was ruling as reperenentitive of her minor son Nalmadi Krishna Odeyar (Krishnaraja Odeyar-IV) and also Nalmadi Krishnaraja Odeyar after attaining majority were very eager to take up large irrigation projects in Mysore state.

In 1801 a proposal was made to construct a 'dam' across Hagari (Vedavati) river which is tributary of river Tungabhadra. After many discussions , revisions , reestimates project was pushed aside without coming to any conclusion. While Hagari was in control of princely Mysore state , Tungabhadra was under British controlled region of Ballari district which was under Madras government. When proposals were made to build a dam across Hagari , near Marikanive of Chitradurga district Madras government objected to it as it would deplete the water to Ballari region. Mysore government established its right over Hagari river through many corridors of power and stages. Ultimately in 1894 the approval was granted to Mysore state to build a dam across Hagari. After technical survey it was found that the proposed dam site does not have firm river bed to support the load of the dam and project was once again abandoned.

In 1898 K.Sheshadri Iyer , Diwan of Mysore formed a technical committee under Col. McNeil Campbell to study the feasibility of constructing the dam at Marikanive. This committee observed that the river bed is laid with hematite , quartzite and schist layers one above the other and these layers are inclined at 70 degress to horizontal. It also concluded that the hematite layer which does not crack under load or dissolve under water covered most part of the dam site hence it can sustain the loads of the dam. The core samples of schist layer which cracks under loading were tested and its Safe Bearing Capacity (SBC) was found to be 65-80 T/Sq.M. The technical committee also observed that due to silting the cracks in schist layers will be sealed controlling the leakage of water in due course of time. On these recommendations the Marikanive project was cleared. Initial construction were started in august month of the same year-1898. The construction progressed under three chief engineers- Col. Mc Neil Campbell , Capt. A.C Joller and Lobbinier- and C.T Dalal was the superintending engineer through out the construction period. [18]

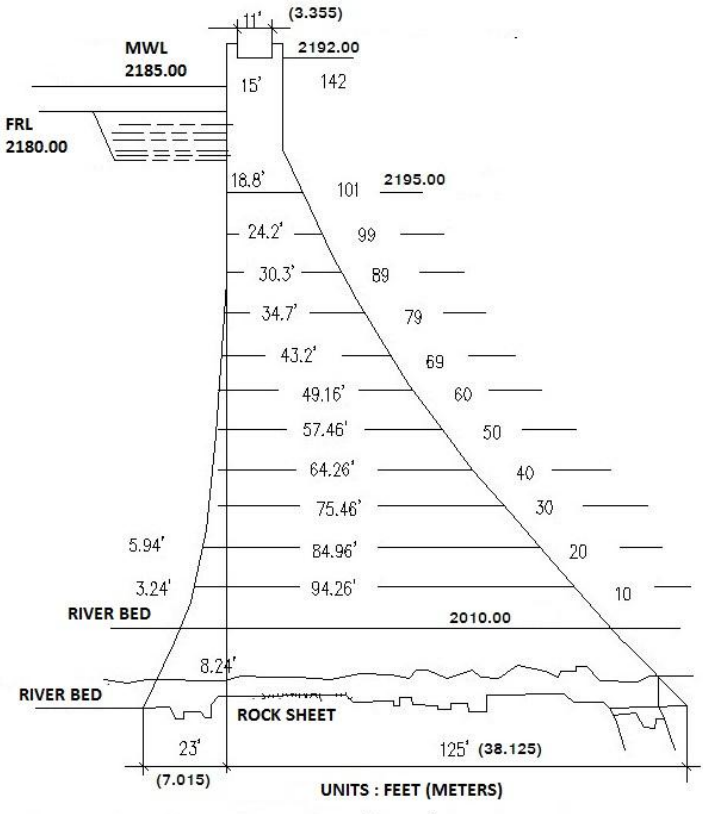
[18] Between 1879-1884 , McNeil Campbell and A.C Joller had completed the construction of 18.3 M high masonry dam near Muchukhandi , near Bagalakote of

Marikanive project provides some interesting facts for engineers. It has 5312 Sq. Km catchment area with the average annual rainfall of 596 MM. 970 tanks with total capacity of 0.184 BCM (6.5 TMC) exist on upstream area of Marikanive dam. In 1876-77 famine no tank in the catchment area received sufficient water resulting in death of 1/3 population of the area.

There was great variation of yield in the catchment area. In 1864 - 0.186 BCM (6.588 TMC) , in 1865 -0.671 BCM (23.652 TMC) water flowed through the river. It was estimated that In the heavy rainfall year the flow would be 0.9 BCM (32 TMC). Yield under failed rainfall - 0.085 BCM (3.0 TMC) , Normal rainfall -0.284 BCM (10 TMC) , good rainfall 0.539 BCM (19 TMC) were estimated. On this basis 0.567 BCM (20 TMC) capacity reservoir was proposed. This capacity is equal to the annual yield of Hagari river.

But during cyclonic rains the probability of reservoir filling full and breching of 970 tanks upstream of the dam site were also considered and maximum flood discharge of 1702 Cumecs (60,000 Cusecs) was fixed for weir design. To enable this discharge it was required to widen the weir beyond dam length on either side by breaking the hard rock. It was also found that raising the dam height to get required width of weir is cheaper than breaking the hard planks on either side of the dam. Therefore the dam of reservoir capacity 1.078 BCM (38 TMC) was approved for construction. The Marikanive dam thus designed has foundation level 8.75 M (25') below river bed level laid on hard rock with maximum height of 50.935 M (167') and can retain water in reservoir for 39.65 M (130')height . At this level capacity of reservoir is 0.918 BMC (32.348TMC). Thus Marikanive reservoir was designed and constructed for multifold capacity than the available water. (Fig : C/S Of Marikanive Dam)

Karnataka. Mc Neil Camp Bell was the superintendent engineer for the Periyar dam construction Project.



VANI VILASA SAGARA DAM CROSS SECTION

As per records the maximum flood discharge in the river never crossed 1004 Cumecs (35377 Cusecs). Even if the design flood of 1702 Cumecs (60000 Cusecs) flow in the river , this entire quantity does not flow over the weir because at this discharge the reservoir spread area increases. The existing weir is 127.5 M (418') long and can discharge 652.6 Cumecs (23000 Cusecs) water. When the depth of flow over weir is 3.05 M (10') , then the flood discharge would be 1135 Cumecs (40000 Cusecs). The sluice which provides water to irrigation canal is 24.4 M (80') below maximum water level. When the water level above this sluice is 3.0 M (10') the

discharge capacity is 29.7 Cumecs (1047 Cusecs) . Since the water to canal is let through sluices from 24.4 M (80') , Stoney roller gates are provided to the sluices.

The capacity of Periyar and Bhatghar reservoirs which were constructed in Madras and Bombay presidency were 0.194 BCM (6.815 TMC) and 0.132 BCM (4.638 TMC). When compared to the other Indian dams , Marikanive reservoir is capable of storing 2 to 3 times the quantity of available water. In contemporary world of those days Aswan reservoir stood first with storage capacity of 1.078 BCM (38 TMC) and Marikanive stood in the second place. While Aswan reservoir filled fully multiple times in each year , Marikanive filled to its full capacity only twice in a century –year 1993 and 2000. Otherwise the storage is around 25%-30 % of its full capacity. Even though the storage capacity of Marikanive is 0.918 BMC (32. 348 TMC) due to positioning of canal sluices only 0.227 BMC (8.0 TMC) of water is available for irrigation. With this quantity only 30,000 acres can be irrigated. If proper canals and methods are implemented this can be extended up to 45,000 acres. The Marikanive reservoir which stood second in position in storage capacity can irrigate only 30,000 acres ! This is the success and failure of the project.

3.5.2.3 Kannambadi Dam (KRS-Krishnaraja Sagara Dam)

Since from ancient times many attempts were made in Karnataka and Tamilnadu to construct 'dams' across Kaveri and its tributaries. 24.4 M high earthen dam was constructed across Lokapavani , tributary of Kaveri in Karnataka at Tonnur , Mandy district. The date of construction of this dam is not known but from other evidences it can be fixed to 12^{th} century. This dam draws our attention for the fact that there is no other ancient dam in India of this height draws our attention. The cross section of this dam provides insights into the pre modern techniques adopted to build such dams.

Technically it is difficult to build dam across Kaveri river as it can be built across small streams or tributaries. In 9th century Madhava Mantri anicut was built using large stones across Kaveri near Talakadu , Karnataka. At same time Kallanai was built across Kaveri river in Tamilnadu. These dams were 3- 5 M in height. The dams higher than this were never built across Kaveri. Mysore administration slipped from Odeyars and came under Hyder Ali and his son Tippu sultan. There are records that Tippu wanted to build a dam across Kaveri. When construction of Kannambadi dam was started in 1911 , the Persian inscription of Tippu dated 1794 was unearthed. By this it can safely be assumed that there was proposal to construct a dam across Kaveri near Kannambadi joining two hillocks. There is no information regarding the type , height of the proposed dam and with whose help it was planned to be built. But from history it is well established that Tippu had cordial relations with French. If Tippu had tried to build the dam with the help of French engineers then he would have been the first person in India to build dam on some engineering and calculations. We do not know the financial capacity of Tippu to build high dam who was always engaged in wars. When Kannambadi dam (KRS) was completed in 1931 , the Persian inscription of Tippu was translated to Kannada and english and was fixed at the main entrance which is at the top of the dam by Nalmadi Krishnaraja Odeyar.

As scientific concepts for constructing barrages and dams emerged a few engineers dreamt of building dam across Kaveri river. Kempa Nanjammanni , Nalvadi Krishnaraja Odeyar and administrators of Mysore state were aware of the construction of large dams as Khadakawasla, Tansa , Bhatghar in Bombay presidency. During 1870 Col. Sankey was the chief engineer of Mysore state. During his extensively travel in the state he had observed many tanks , reservoirs built across small and medium sized streams. He appreciated the locations chosen and local technology adopted to construct earthen bunds. Sankey made a proposal to construct a large dam across Kaveri river. The survey works were taken up , the dam location was identified near Ramaswamy Kanive which was on the border of Mysore and Madikeri states. The initial estimates

were made and due to high cost the project was pushed aside. After retirement of Sankey , in 1885 Col. Bowen became the chief engineer of Mysore state. He deputed executive engineer Mc. Langhin on special duty to prepare a project report for construction of dam across Kaveri through which drinking and irrigation water could be supplied to Mysore city and surrounding areas. This report was also abandoned on cost reasons.

Kempa Nanjammanni (Vani Vialasa Sannidhana) ruled on behalf of minor prince Nalvadi Krishnaraja Odeyar until 1910. During this period she took up many progressive and welfare projects. Marikanive reservoir and the first electric generation Station in India near Shivana Samudra were two among such many works. In 1898 Marikanive dam construction costing 37 lakhs was started. Due to this projects on Kaveri river took back seat. During this period K.Sheshadri Iyer was the Diwan of Mysore. Shivana Samudra hydro power project work which started in 1901 was completed in 1902 with immediate generation of power. An agreement was made with John Taylor & Co. who were the mining contractors for Kolar Gold fields to supply the power generated in Shivana Samudra. John Taylor company was using electric generators and equipment for higher production for which 314 KWh (32000 HP) power was required. Even though it was not difficult to supply this power during rainy season but when the flow in the river fluctuated the power supply followed it. John Taylor company threatened to terminate the agreement and sue Mysore government in London court if the assured power is not supplied within July 1914. As an immediate solution 2.44 M high (8') , 701.5 M (2300') long dam was built near Shivana Samudra to store the water and the required power was supplied from 15 July 1908. Mysore state as well as Johan Taylor Co. knew that this was only a temporary solution.

It was very clear to Mc Hutchin , the chief engineer of Mysore state that only by constructing a dam across either Kaveri or one of its major tributaries continuous power supply could be assured from Shivana Samudra. Mc Hutchin deputed superintendent engineer

V.H Karvy to prepare a project report for this. V.H Karvy , carried out the survey once again and reported that site near Ramaswamy Kanive is not suitable for large masonry dam as there is no rock in river bed to carry the loads of the dam and also he observed that if dam is built in that place the land which does not belong to Mysore state but which in independent Madikeri state would be submerged which may bring political complications. V.H Karvy identified other two locations for dam construction. Among these two the location near Kannambadi was recommended by Capt. Nikholas Bernard Dawes , Deputy Chief Engineer of Mysore state. W.F Smeeth , geologist of government Geology Department inspected the site and cleared it as the river bed is laid with strong rock which can support dam loads. After going through these McHutchin approved Kannambadi site and directed Deputy Chief Engineer Cap. Nikholas Bernard Dawes to prepare the detail project report in 1907. On 25/7/1908 Nikholas Bernard Dawes submitted the report.

The highlights of Bernard Dawes report were thus – in first stage 21.35 M (70') high dam near Kannambadi to be built to store water to generate power in Shivana Samudra. From this 226 KW (23000 HP) power can be generated. After catering the needs of John Taylor Co. the remaining power to be sold to Coimbatore in Madras province. The amount so collected to be used to raise the dam to 35.075 M (115') in second stage. 30,000 acres of land can be brought under irrigation after completion of the project.

Total 1.75 crore Rupees is required for the entire project. In 30 years , the investment made and interest on it will be returned. From 39 th year the irrigation canals will be completd. From 40th year through electricity sale and irrigation tax Mysore state will get annual revenue of Rs. 60 lakhs out of which 8 lakhs is required for maintenance-these were the financial implications and highlights outlined in Bernard Dawes report. Young ruler Nalvadi Krishnaraja Odeyar felt that the project which requires huge money is not really benefiting his subjects and abandoned it. In 1908 Mc Hutchin retired and Nikholas Bernard Dawes was appointed as

Chief engineer of Mysore state. Bernard Dawes had bitter experience of rejection of his report. Therefore he prepared revised report and submitted it in 1909.

The main features of revised report were : (1) Constriction of 27.45 M (90') high dam near Kannambadi in first stage which can be raised to 36.6 M (120') in second stage. (2) Storing 24.4 M (90') and 35.99 M (118') depth of water in first and second stage. (3) When second stage is completed the capacity of the reservoir is 1.053 BCM (37.1 TMC) (4) From the stored water 451.26 KWh (46000 HP) power can be generated. (5) From sale of each HP of power generated Rs 10 dollor can be earned. (6) Irrigating lands in Mandya , Nagamangala , Channapattana Taluk through 160 KM long canals. The point (6) was added to please Nalvadi Krishnaraja odeyar so that he will accord permission immediatelty. The total estimated project cost was Rs. 2.5 Crore. By seeing this Mysore government shivered because the total annual income of the state itself was not so much. In the first report of Bernard Dawes there was no benefit to Mysore state but in second report there were benefits to the Mysore state especially farmers. Kempa Nanjammanni observed this and she made firm decision to realize the project.

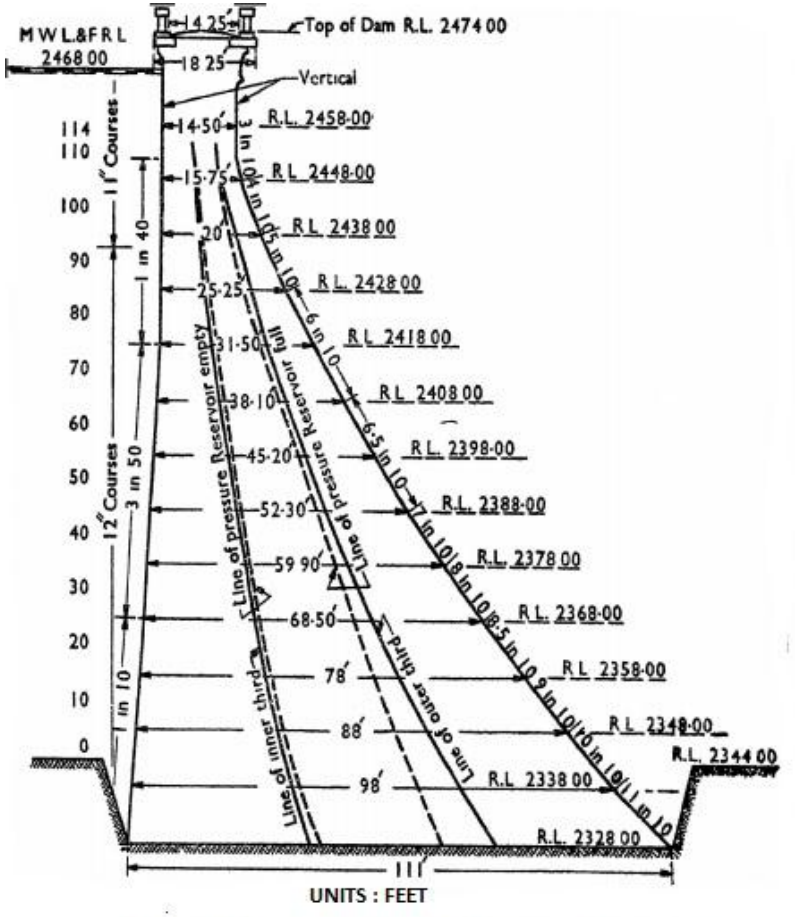
In 1909 cracks appeared in a small dam built across Kaveri river near Kattepura of Arakalagudu Taluk, Hasan district and some portion of it was also breached. To close this breach and repair the damaged portion of the dam Chief Engineer Bernard Dawes along with 7 labors went to water on 30/07/1909. Transporting boulders in barrels over two rafts bound together to the damaged portion and closing the breaches was his plan. After unloading the barrels to the river bed he wanted to pull them towards the central small 'island' like area through bigger rafts. When the barrels were being pulled towards the island the flood water raised in the river rocking the small rafts. In commotion labors moved with commotion resulting in toppling of raft. All labors including Bernard Dawes were in floods. Except one who was crying for help others swam to the banks. In a bid to save him Bernard Dawes

swam towards him and tried to pull him to the bank. But Bernard Dawes failed in his attempt and was washed away in flood. After three days body of Bernard Dawes was found on downstream area in rotten condition. The locals who were moved by the sacrifice of the 'white man' who gave his life to save a native labor collected 600 Rs. deposited it in government bank at 6.5 % interest. This interest was given to the students who showed valentary acts. (122)

After tragic death of Bernard Dawes the post of Chief engineer of Mysore state was vacant. Maharaja Nalavadi Krisnanaraja Odeyar wanted to bring Indians for the post. As a result of this on 15/11/1909 M.V was appointed as chief engineer of Mysore state. When M.V assumed office Bernard Dawes report was on his table. This was the original source for further works of M.V. To give final shape to Bernard Dawes report survey was ordered by M.V in 1910 . By 5/5/1991 revised report was ready and on October , 1911 approval was accorded for first stage with budget of 80 Lakhs rupees and work started immediately. By 1914 the toughest foundation work at the bottom of the river bed was completed. Also the dam was raised to 18.3 M (60') on southern portion and 10.98 M (36') on northern portion. By 1915 dam rose to a height of 19.825 M (65') . By this time scour sluices were provided in the dam body and water flow was controlled. When the first stage of construction was completed by reaching 24.4 M (80') height in 1920 the storage capacity was 0.313 BCM (11TMC). (122)

To decide the further works of dam construction , irrigation etc., a committee was formed under Frederick saint John Gebbi in 1922. In 1932 dam reached height of 40.26 M completing the construction activities by which the original amount earmarked for the original project was completely utilized and the canal works were yet to be started. In 1929 high level canal works started. At the same time 1220 M (4000') length of proposed 2806 M (9200') long Hulikere tunnel was completed. In next decade the canal works progressed in stages and by 1940 all works were completed.

The dam constructed continued for 21 years during which eight chief engineers took the lead. (1) Sir M.V (2) Rajasabha Bhushana Karpura Srinivasa Rao (3) Rajashilpi Visharada Bahaddur Subba Rao (4) Rajasabha Bhushana I. Cadamtri (5) Raja Sabha Bhushana Rao Bahaddur Krishna Iyengar (6) Rajasevasakta John Bore (7) Rajasevasakta Diwan Bahaddur K.R Sheshachaar and (8) S. Srinivasa Iyer (Fig : C/S Off Kannambadi Dam)



KANNAMBADI (KRS) DAM CROSS SECTION

Technical Aspects

In 'Memoirs Of My Working Life' M.V writes thus : There was a proposal to build a reservoir at a village called Kannambadi 10 miles west of Seringapatam (Sri Rangapattana) , but no design of practical value had been actually prepared ……As I had visited large irrigation projects like Aswan dam in Egypt in course of my tours and I had done some work connected with designing large reservoirs in Bombay presidency and Hyderabad , it did not require much time for me to prepare suitable designs and a complete project both for irrigation and power generation best suited to the Kaveri valley in Mysore…. I did not know whether His highness Maharaja or his other advisors consulted outside engineers or not, but it served my purpose to find that the scheme submitted by me to the government was sanctioned without any addition , omission or alteration'. M.V has squeezed the entire Kannambadi project including design and execution into these two sentences. It is very surprising that M.V has said so lightly about the project which brought him the national fame. Some may suggest that this shows the simplicity of M.V. But different questions arise in the technical background. [19]

[19] William Willcocks who served in India was promoted to post of 'Director General of Study' and was transferred to Egypt to take up the irrigation works on Nile river. Under his guidance planning ,design and execution of dam along with irrigation works were carried out. William Willcocks published book titled 'The Nile in 1904' in 1905. Engineer Henry Lyons reviewed this book and made observes that it can not be said that book either provides correct or complete information on the project. No cross references , notes, indices are provided. Therefore there are intricate errors in the design of dam itself. William Willcocks should provide additional information to justify his approaches and methods. William Willcocks replied to each technical pointb raised by Henry Lyons. But both of them did not come to any consensus. To identify the real issues between the argument of these two expert engineers Egypt government constituted a technical committee in 1918. William Willcocks declined to appear before the committee on the pretext that they had biased opinion against him. (41-163)

(1) On 15/11/1909 M.V assumed the office of chief engineer. There was already a report on Kannambadi project. M.V says that no design of practical value existed but he prepared it. M.V never names the engineer who prepared the previous report , he never informs why that report was not of any practical value, never talks about the project cost estimated in that report. M.V does not mention the team and names of engineers in it who were assigned to prepare revised 'practical' project. M.V projects himself as unaided hero who single handedly prepared the detailed project report with mere time span of one and half years without taking the help of previous reports. Even today with the help of latest survey equipment , computers, the preparation of Detailed Project report for projects like Kannambadi require more than two years. During those days it is very natural that it took twice the time. Therefore many statements given by M.V has to be taken with some salt.

(2) M.V has recorded that until 1912 no dam was constructed which was comparable to Kannambadi. We do not know on what parameters he is saying that. Because a dam is always attached with a reservoir. The storage capacity of reservoir depends on the depth of water and spread area. The height of dam depends on the topography of the area chosen to build the dam and valley through which river flows. If suitable location is available large quantity of water can be stored with dams of small heights. At some area the dam height may very high but the storage capacity may be low due to topographical features. From engineering point of view height of the dam pose challenges. The capacity of Kannambadi reservoir was highest in India during those days. This was due to the location of dam and other topographical features. The technically challenging dams of greater height were already constructed in India before Kannambadi dam.

(3) The height of Marikanive dam is more than Kannambadi dam and technically it was more complicated. Kannambadi dam is 44.53 M (146') high from founding level and 40.87 M (134') from river bed level. These measurements were 53.68 M (176') & 48.19 M

(158') for Periyar dam which was completed in 1897 and 49.87 M (163'4") and 43.31(142') for Marikanive dam which was completed in 1907. Kannambadi was not the biggest dam of the day. The construction cost per Cu.M of Periyar , Marikanive and Kannambadi dam were 24.14, 8.6 & 29.62 Rs. From design point the toe and heel stresses in these dams were 0.82 MPa, 0.92 MPa and 0.98 Mpa.

(4) As per available records while designing Kannambadi dam : (1) M.Bouvier and Unwin formulae were used to determine the maximum stresses (2) Huggs expression was used to calculate the wave forces on the dam. (3) The maximum stresses in toe and heel were restricted to 0.068 MPa. (4) From M.Bouvier method the principal stresses induced on cross section which is 36.6 M (120') below the top of the dam were calculated as 0.093 MPa. (5) No uplift forces were considered on the assumption that the dam is built on waterproof sheet rock.

(5) All large dams built under British administration were reviewed at multiple levels. Even the designs approved at chief engineer level had their controversies. These controversies and discussions were very valid and contributed a lot to engineering advancement. The opinion was sought from Professor Rankine as answer for the questions that rose during designs are historical which helped to adopt new understandings , scientific methods in engineering. The arguments put forward by Pennycuick shows the importance and value of technical review at multi levels. [20]

[20] Mysore Engineers Association was formed in 1907 under the guidance of chief engineer W.Hutchin. Cap. Nikholas Bernard Dawes , C.M Shastry , B.C Srinivasa Iyengar of Public Works Department were the main promoters for this. The main aims of the association were : (1) To supply necessary sources to know the technical advancements made through which they can solve the technical problems encountered in practice. (2) To motivate engineers to think in alternate ways for developmental acitivities of the state. (3) Establishing professional contact among engineers. M.V was head of this association between 1910-1912. In 1941 Nalvadi Krishnaraja Odeyar donated land and money to the association to have their own building. (Institution of Engineers (India) Ltd., building on

M.V assumes that his visits to large dam sites , collected reports qualifies him to design huge dams. As we have already seen in Osman Sagar , M.V did not have expertency in dam design. All the large dams built under British in India & outside , also large dams built in European countries , USA were subjected to expert review. M.V does not show any patience to subject his designs to the experts review but adamantly wanted them to be implemented immediately. The attitude shown by M.V to execute the project in his own way is not acceptable where the public funds and interests are involved. Even though M.V had designed Osman Sagar dam it was not yet constructed completely. As already seen the designs of Osman sagar dam were not correct. M.V wanted to execute the project which crossed the annual income the state without any peer review or discussion.

(6) Many dam design methods such as Sazilly , Dolecre, Rankine , Krantz , Halracher, Crugnola, Bouvier, Molesworth were available to engineers. Each of these engineers proposed their own methods on some basic assumptions and principles. Since many methods were available an engineer before taking up the design shall clarify what methods he is going to adopt and why he chooses it. In Periyar dam design even though Pennycuick adopted Molesworth method , he did not forget Rankine and Dolecre principles. Twelve years before Pennycuick had argued that since the Molesworth method does not account for practical situations it consumes more material.

As in India the second half of 19th century and first two decades of 29th century were the golden days of dam construction in USA. In the same period 54.3 M (178') high Quaker dam project was

---

Ambedkar Road). In 1960 this association was merged with Instituten of Engineers (India.) We do not know whether Mysore Engineers Association discussed Block Irrigation system, Design and execution of Kannamabadi, Osman sagar dams , Bhadravati Iron Works project of M.V. or fearing the position of M.V sang in chorus in prasing and euologing him.

proposed. Comprehensive technical discussions were made during the design stage. The methods to be adopted , formulae to be used , the materials to be used , the control of construction activity , quality assurance , the experienced so for gained , the comparison of that experience with proposed Quaker bridge were compiled in comprehensive manner and kept before public and experts. The Public Works Department of USA sent his engineer E.S Cheshbrough to Europe to know more about dam design and construction and collect the information. A. Fteley , an external , independent Consultant was appointed to review the designs. A. Fteley submitted his report to B.S Church , Chief Engineer of Aqueduct Commission on 25/7/1887. In opening pages he has recorded thus. [21]

"…..that this subject shall be exhaustively studied and the amount of money involved is so large that the necessity of acquiring a full knowledge of the practice followed by the other engineers in similar instances became at once evident …. Owing however to the unprecedented magnitude of the proposed dam , which give rise to some important problems heretofore unsolved, it becomes necessary , in some instances , to leave the beaten path and resort to a basis of operations different from that established by others"

Before A. Fteley prepared his report the engineers team of Public Works Department had studied the project deeply , designed the dam as per various expert opinions and did compare them. More than 15 recommendations given by experts were incorporated. Even though the department had previous experience of design and construction of dams it engaged third party expert consulting civil engineer to know the defects in their design if any , to understand the latest developments. Because of this it came to known that uplift forces were not considered in previous designs.

[21] Quaker Bridge Project was abandoned in future days but Crotan dam of same capacity and size was constructed.

The inevitability of these forces was recognized and included in the design.

Irrigation department of Egypt after preparing the detail report of Aswan dam and Nile valley projects formed a committee of three expert civil engineers to review it. Garstein , the under secretary of Public Works Department ,Egypt, who himself a civil engineer recorded that ' there is nothing as such we do not have confidence on completeness of the project or technical aspects of it. But it is our stand that before taking up such large projects it is better to take the opinions of the experts of subject in the world and make them to agree to our final decisions.

(7) As cross reference to Kannambadi reservoir M.V has invoked Aswan dam. Aswan and Kannambadi dam both have similar challenges of design . In both of these dams for flood discharge the vents are provided in the body of the dam. But M.V has not adopted the design principles which were recommended for Aswan dam.

(8) The water which seeps below the foundation exerts uplift forces which are detrimental to the safety and stability of the structure. Under uplift forces Bouzy and Habra dams were breached and failed in 1895. By 1895 the engineers who studied the phenomenon of uplift recommended to consider it in designs or to provide drainage galleries to relieve the uplift pressure. Wyrvy dam constructed in 1892 had such arrangements.

Two dams which were built in USA without considering uplift forces failed and in 1895 Pensylvania government made law to bring all dam designs under government control. Even though the dam is constructed on solid rock through which water cannot leak and construction is carried out with utmost care nobody can say with full confidence that water does not seep in future. Therefore consensus was reached that all dams shall be designed for uplift forces. (33,56) Sazilly , Delocre , Rankine , Krantz , Harlasher , Crugnola , Bouvier , Molesworth methods neither include these forces nor recommends for drainage. By considering Kannambadi

dam is built on solid rock M.V neglected uplift forces which other engineers declared as critical.

Construction of Mettur dam started in 1927. But the designs of it were finalized by W.M Ellis by end of 1910. Due to dispute over sharing of Kaveri water this project did not take off until 1923. Mettur dam was designed by using Unwin and Bouvier methods similar to Kannambadi dam. Mettur dam was also constructed on solid rock. To control seepage of water the all the precautions which were taken for Kannambadi dam were also taken for Mettur dam. But as per the observations made by expert engineers elsewhere , drainage galleries were provided in Mettur dam. M.V neither considered uplift forces nor provided drainage galleries.

(9) Between 1904-07 the studies made on dam models by L.W Atcherli , Carl Pearson and team established that stresses induced on the vertical plane of dam toe are critical than the those on horizontal plane. John Sijesmund and team who carried out similar studies independently came to same conclusions. Drapers company which was expertised in dam construction carried out tests in 1906 and concluded that the stresses determined in design of Aswan dam (Sazilly, Dolecre, Rankine, Bouvier) does not represent the actual induced stresses.

After this civil engineering community came to consensus that the responsibility of the engineer does not end by following the regular design methods but he has to take count of latest research results also. When proposals were made to raise the height of Aswan dam in 1907 , calculations were made to check the safety of the dam in the light of new findings. (56,57,58). This new knowledge was not employed in Kannambadi dam design.

(10) M.V provided earthen bunds on downstream face of Osman sagar dam for additional 'safety' against sliding. But same M.V does not resort to any such measures in Kannambadi dam. M.V was head of advisory committee for Tippagaonadanahalli dam (Chamaraja sagara Dam). Here also he has not recommended 'great bund' for safety. Therefore it is very clear that the M.V was

not confident of his designs when did for Osman Sagar dam for the first time.

(11) In last decade of 19th century engineers recognized the importance of seismic effects on the dam and its design, But proper theories were not formulated to consider them in design. M.V 'a great dam engineer' never thought or discussed with anybody about seismic forces and methods to implement them in design.

(12) M.V was directly copying European models of engineering and industrialization. The British models of irrigation were the source of M.V's irrigation knowledge and experience. In Europe and USA the design of large dams were reviewed by expert committees or expert consultants before construction. In this view it was the responsibility of M.V to send his designs to be reviewed by experts. Instead of that by saying ' I did not know whether His highness Maharaja or his other advisors consulted outside engineers or not, but it served my purpose' M.V has escaped from his responsibilities.

From the above discussed technical points regarding Kannambadi dam design it is very clear that as believed M.V was not always eager to acquire new technical knowledge and eager to implement it. Instead of being disgruntled for not receiving immediate response from Maharaja after submitting report , it was the duty of M.V to have the review on his designs from experts. Review from experts would have helped to the improve the design concepts and economizing the project.

A sketch engraved over marble slab is fixed on the entrance of the Kannambadi dam which shows the dam cross section with resultant lines of force lying within middle third of the base under reservoir full and empty conditions. The engineering drawing of the same has been provided for reference. The resultant shown in the sketch has been obtained from Unwin and Bouvier methods. These methods does not consider the opening in the body of dam. When considerable sized openings are provided in the dam body , the hydrostatic thrust cannot pass through them. Therefore the

hydrostatic thrust is transferred horizontally to the portion of dam on either side of the opening. This condition requires thickening of dam –buttressing- on either side of the opening. Kannambadi dam has not been designed with this condition . Therefore the designs done by M.V for Kannambadi dam are wrong. If M.V had sent his designs to experts they would have recognized this technical error.

From engineering point of view Kannambadi dam designed by M.V does not consider any new finding. This bursts the carefully fostered myth that M.V wandered the world to understand the latest developments in engineering. The Table provided Appendix provides the exhaustive technical details of various dams constructed in India and abroad during the same period. From it is evident that Kannambadi is not the work of a great 'genius' as propagated.

(13) During 1930's N.S Govinda Rao earned engineering as well as A.I.M.E degrees. He applied for the membership of Institute of Engineers.To get membership of the institute the recommendations of six member engineers was required. For this Govinda Rao approached M.V and Col. Flat. Some sources inform that before giving introduction letter M.V called Govinda Rao and asked him to give his opinion on technical shortcomings in design and execution of Kannambadi dam and both of them discussed the issue for more than 45 minutes. .

By 1911 the design of Kannambadi dam was finalized. M.V did not considered some design aspects which were recognized critical by other expert engineers. Did Govinda Rao highlighted them ? If so what were the reactions of M.V ? The design and construction of Tippagonadahalli Dam (Chamaraja Sagara reservoir) started at the same time . M.V was the president of the committee for project. In Tippagonadanahalli dam the not only uplift forces were neglected drainage galleries were also not provided.

(14) The Automatic gates installed by M.V on Kannambadi dam to maintain maximum reservoir level during floods are superfluous and does not help in any way to maintain water level in reservoir.

Without other mechanically operated gates in the dam these automatic gates are useless and additional burden. This can be seen from the following calculations.

Maximum Reservoir Level – 2468' (752.75 M)

River Bed Level = 2344' (714.92 M)

Maximum Water Level = 2468-2344=124' (37.82 M)

OPENINGS-GATES : DISCHARGE CAPACITY

No/Detail	Sluice Level M (Ft)	Sluice Size M (ft)	No. of sluices	Total Area of sluice Sq. M (Sq.Ft)	Discharge Capacity Cumecs (Cusecs)
1 (Scour Sluice)	3.66 (12')	1.83x3.66(6'x12')	8	53.58	851.63 (3752)
2 (Scour Sluice)	15.25(50')	1.83x4.575 (6'x12')	3	25.12	106.93 (3770)
3 (Turbine Sluices)	16.165 (53')	1.83 Dia (')	4	10.46	33.10 (1167)
4	18.3 (60')	1.83x2.44	1	4.46	52.97 (1860)
5	18.3 (60')	1.83x3.66	3	20.09	66.94 (2360)
6 Openings-flood	24.4 (80')	3.05x6.1	16	297.68	3450.08 (121920)
7 Openings-flood	31.415 (103')	3.05x2.44	48	357.22	2908.80 (102528)
8 Openings-Flood	32.33 (106')	2.44x3.66	40	357.22	2020.00(71200)
9 Automatic Gates	34.77 (114')	3.05x3.05	48	446.52	1290.75 (45504)
Total (6,7,8,9)				1458.64	9679.37 (341152)

The Discharge capacity of Automatic Gates = 1290.72x100/9679.37 = 13.33 %

Automatic gates can discharge 0.112 BCM (3.93 TMC) of water in a day.

The capacity of Kannambadi dam is listed below :

Level 2468 (124' = 37.82 M) =0.0387 BCM (1.366 TMC) -

Level 2469 (125'=38.125 M) =0.0396 BCM (1.398 TMC)

Level 2470 (126'=38.43 M) = 0.0404 BCM (1.425 TMC)

When the inflow into the reservoir above the maximum reservoir level is more than 0.6 M (2') (1.398+1.425=2.823 TMC) then the flood gates have to be lifted to discharge the water because the maximum capacity of automatic gates in a day is 3.93 TMC. Since the reservoir level fluctuates during rainy season and the inflow may cross 3.93 TMC in a day the system has always to be ready to open and close the mechanically operated gates. When the water in the reservoir is below the maximum level the automatic gates are inactive. As per the agreement made with Madras government irrespective of the level of water in the reservoir the fixed quantity of water has to be left. This possible is only by operating the mechanical gates. Therefore automatic gates does not relieve other gates from mechanical operation. Hence the utility of automatic gates of M.V to control the floods is very limited. The situations in Khadakawasla and Kannambadi were totally different. In Khadakawasla designed length of weir was provided over the dam to discharge flood water. The problem in Khadakawasla was to raise the reservoir level and It did not require to discharge the controlled quantity of water in stipulated time to the river, when the reservoir level was below MWL.

It was sufficient to increase the size of the openings at 24.4 M (80') , 31.415 M (103') and 34.77 M (114') level by 4.76 % (3450.0x13.34/9679.36) , 4 % (2908.80x13.34 /9679.36 and 2.78 % (2020.00 x13.34/9669.96) . Then the size of each opening would have increased by 0.15 M (6") . Instead of this by installing automatic control gates unnecessary complications has been brought into operation and control.

(15) Lime surki was used as binder for masonry in the construction of Kannambadi dam. In Karnataka legends were fabricated that the surki is better than cement and M.V's geniusness has been shown in using surki and there is wide spread belief that Kannambadi is the only dam where surki was used.

When lime stone is burnt in kilns using charcoal/coal/firewood the 'burnt lime stone' is produced. By adding correct quantity of water slaked lime is produced. By grinding this slaked lime with sand and burnt clay in correct proportion surki is produced. By this technique surki mortar was produced in India since from ancient times. Surki was used in construction of the ancient buildings and temples. The main gopura of 10 th century Jagannatha Temple in Puri , Orissa is finished with surki mortar in many layers.

Through 'Ganapati Best Portland Cement' company in Porabunder of Gujarat , India entered the era of cement. In first year the company produced 950 T of cement and to meet the demand it imported 150530 T . Cement manufacturing requires high initial investment , technical knowhow and skilled work force. These were not easily available in India in the beginning decades of the 20^{th} century. The imported cement was always costly. The large dam projects require huge quantity of cement. The large projects were always lagged the schedule due to shortage of funds. Therefore it was not possible to use cement in dam construction due to economic reasons. Therefore British engineers preferred economical surki which can be manufactured using locally available material at site. And also there was not much scientific knowledge which compared the merits and demerits of surki mortar and cement mortar. Therefore until first half of 20^{th} century surki was preferred in dam construction. In Periyar dam cement concrete was used in the portions which were less stressed. In 1890 Beetalu and Zeelang dams in Australia were completely constructed using cement and equipment. But this was not possible in India from economic reasons.

In all large dams –Khadakawasla, Tansa , Bhatghar , Periyar , Betwa-surki mortar was used as binder for masonry work. In Tansa dam construction locally available lime stone called 'kankar' was washed , burnt in kilns , slaked and mixed with clean sand in 1:1.5 proportion and was ground to obtain surki mortar and was used as binder. In begining decades of 20th century surki was inevitable material to achieve economy and there was no technical superiority in it when compared to cement.[22]

(16) While telling about Kannambadi M.V has declared that since he had visited Aswan dam project site in Egypt during his tour , he had confidence to design Kannambadi dam. M.V's visit to Aswan was part of his second foreign tour to the west during 1908-08. M.V has recorded his foreign tour in chapter 16 of his book through the observations made , the technical advances encountered , the places visited , the important persons met etc., In this chapter the details about paper and automobile industries , irrigation , water supply systems , the economic conditions of various countries , the industrial policies are given. He also referred Croton dam built to supply New york city and commented that the irrigation engineering has not well developed in USA.

M.V was a civil engineer who had experience in irrigation , water supply , sewerage , road & building construction etc., Beyond this his interest in mechanical , electrical engineering was limited to establish industries and he had neither experience nor expectancy in these fields. In Nile valley project British engineers from India played the major role. It was possible for M.V who was still in service under British government to obtain much more technical details in dam construction and irrigation engineering. In such circumstances it was natural that the details of Aswan dam , the experience gained at project site , the opinion of expert designers,

[22] During construction of Marikanive dam Mysore engineers were successful and gained expertancy in manufacturing consistent quality Surki mortar in large scale. This was directly used in Kannambadi dam construction.

builders of the dam would have got preference and prominence over others. But as a surprise M.V have not written a single line about these. He only knows why he did not write .

The attitude of M.V regarding non-technical aspects of Kannambadi dam are also very interesting.

(1) Civil engineers always have their own grand concepts which appear as projects and reports. They will be very enthusiastic to execute those projects. They always dream to construct huge dams across rivers, canals, tunnels , large bridges , buildings etc., which also help the advancement of the country. But such projects cannot be taken up immediately as wished due to economical , natural , political, social obstacles and constraints. The engineers who proposed large projects and pressed for their implantation also knew the restraints and waited patiently for the right time. They were also ready to modify , correct and reduce the project size to match the economical constraints.

Even though large projects are technically sound , can bring welfare to the society , acquiring the funds is on the shoulders of administrators. A project however it may be pro people , there will always be challenge to administrators to execute it without affecting the other social activities and taxing the citizens adversely. Therefore the large projects are never executed immediately after proposals from engineers.

By 1875 British government cleary declared that an Indian engineer shall know that there is no sufficient money for irrigation projects and he must exhaust all ways and methods to complete the project within the available money. In the background of this caution policy often the size of the projects , their estimate were being revised many times. The British government accorded approval to the projects which came within the fixed limits otherwise the scope was reduced or project was postponed.

In British administration , British engineers were preparing project reports for irrigation , dam construction etc., and submitting for

approval. Almost all the large projects were either rejected or postponed in the beginning citing financial constraints . Khadakawasla , Bhatghar , Tansa, Periyar , Bhakra-Nangal projects were suspended for a long time due to their project costs. When M.V was serving the British , he followed their 'cost restriction ' guidelines silently without raising a word. Soon after assuming the office of Chief engineer of Mysore state M.V forgot all the experience gained in British service regarding the delays, reduction in scope and cost cutting of projects.

The cost of the project prepared by M.V was 2.53 Crores which was more than the annual income of Mysore state. Therefore Maharaja did not give clearance to the project immediately. Maharaja had every right and responsibility to know the effect of pouring entire state earnings on a single project. If one observes that two decades before Madras government which had better resources and revenues was afraid to take Periyar dam project at 65 lakhs cost , the concerns of Maharaja were genuine. [23]

[23] By 1910 there were total 565 princely states in India. Among these Baroda (Area : 20734 Sq.Km, Population : 19.5 lakhs , Annual Income : 1.23 Crores , Honour : 21 cannons) , Hyderabad (Area : 211706 Sq.KM . Population : 1.12 Crore , Annual Income : 3.59 Crores , Honour : 21 cannons) , Jammu & Kashmir (Area : 207104 Sq.KM . Population : 2.91 Crore , Annual Income : 87 Lakhs , Honour : 19/21 cannons), Mysore (Area : 75736 Sq.KM . Population : 55.3 lakhs , Annual Income : 1.9 crores , Honour : 21 cannons) were the first four largest princely states. Remaining 9 states (Annual income : 50 laks-1 crore) , 20 states (Annual income : 25-50 lakhs) , 33 states (Annual income : 10-25 lakhs) and 499 states (Annual income : Less than 10 lakhs) were of smaller strength. In 1910 except Mysore and Hyderabad which had annual income of 1.9 crores and 3.59 crores no other princely state had the capacity to take up and complete the large projects like Kannambadi. The financial capability of Mysoe state enabled it to take up progressive works such as Marikanive project , extension of railway lines , hydroelectric power projects.

Madras Presidency and Hydreabad princely state were large political units. By 1894 there were proposals to construct a dam across Tungabhadra rivera near Hosapete but were abandoned on financial grounds that it would bring low annual interest return of 3.4 % . In 1885, 1889 , 1897-98 attempts were made to implement this project. In 1902 Irrigation Commission which understood the

(2) M.V had estimated Rs. 2.53 crores for the project. But the unpredicted circumstances which may arise during large dam projects may overrun the estimates was known from the Aswan dam project. In Aswan project the firm rock bed required for dam foundation was not available as estimated in the report. As consequence of this the foundation was taken 20 M below the proposed level. Due to this the cost escalated and uproar was raised in the administrative circles. British who colonized many countries were struggling to provide additional funds and were trembling in case of such cost overruns which were not included in original estimate. M.V without thinking properly about such situations , threw away the prepared project report and went on tour in ire /umbrage/dudgeon. This incident questions the maturity and integrity of M.V. While boasting about his capacity M.V tactically silent on the unpredicted challenges that may arise and probable solutions for them.

(3) In 1894 Nile project and Aswan dam construction were approved. In 1897 the initial works to take up the construction came to a final stage. Since the cost of the project was high many alternative ways were searched to mobilize the funds. In February , 1898 agreement was made with John Aired Company under the condition of completing the project by 1/7/1903. As per this agreement contractor has to build the dam in his own cost and transfer it to the government. And also the government has the right to approve construction quality and serviceability. In return, government has to repay the contractors a total amount of 2.4 crores in a period of 30 years , in installments of 3 lakh pounds. Thus through alternative funding methods Aswan dam was constructed.

---

importance of the project recommended to study the technical aspects in detail. In 1905 meetings were held between Hyderabad and Madras presidency and Tungabhadra project report was prepared. As it was financially not attractive British government recommended to defer the project for next 15-20 years. In 1944 water sharing agreements were made between Madras and Hyderabad governments and project took off in 1948. For financial reasons Tungabhadra project was deferred for almost 100 years.

M.V never tried to mobilize the funds from alternative sources as in Aswan project through various methods such as long term loans, issuing government assured irrigation bonds to the companies/rich or the long term water supply agreements. As a contrast to this one has to look at Pennycuick who built the Periyar dam. The reports that when pitched against the non-cooperation of British government to provide funds for dam construction , Pennycuick and his wife tried many ways to mobilize the amount and even they sold their property in England call for our attention.

As chief engineer of Mysore state M.V was more powerful than Pennycuick. There are evidences to prove that M.V knew many rich , powerful and famous in Bombay. Even so without proposing alternative ways to mobilize the funds M.V tried to pressurize Maharaja through tantrums. Thus M.V looks dwarf. When Maharaja did not approve the project immediately , M.V was upset fully , lost interest in daily works , applied for vacation and went to north India tour-which reflects the mind set of 'great engineer'. Before and after independence engineer have prepared many such projects but nobody has behaved like M.V.

(4) On 27/3/1913 , 6th Session of Mysore Civil Engineers Association was held. While speaking to the engineers M.V observed that a paper has been presented to utilize water for sugar cane cultivation . He also said ' I notice that there is no paper on agenda on masonry dams. I presume the engineers have been too busy with construction work to find the time to write a paper on the subject ; but I trust this omission will be supplied at the next year's conference'. It is very sad that M.V who is considered as the disciplined veteran who recorded all important facts , was chief engineer but has not brought the report which provides the complete picture on the design and construction of Kannambadi dam. It seems that he did not used his power to bring out such a document. Except one cross section of the dam carved on marble panel nobody knows where the other important technical documents are available. It is certain that the engineering associations which eulogy M.V have also not seen any such

technical documents. Therefore Kannambadi , Automatic gates which are identified with the achievements of M.V have become the subjects of worship instead of engineering study.

(5) Not much technical information is available on construction of Kannambadi dam. Were explosives used to remove the rock for preparation of foundation bed ? who carried such operations ? Who formulated the safety regulations for it ? what were the practical challenges in the construction work , how they were addressed – such information is not available. There are no write ups on construction activity. M.V dishearten us much by not providing us the vital information such as -the specifications followed during construction , if contractors are engaged the terms and conditions laid on them , the actions taken for welfare of labors during construction , the method followed to obtain fire wood to burn lime stone , the area recognized for that and the extent of forest lost , the side effects of it etc., . But in contrast the complete technical details of the projects executed in other countries and other projects in India are available as contemporary book , report , article , write up etc., As on date it seems that no civil engineer in Karnataka has seen the original design documents prepared by M.V and nobody knows where they are.

The photos , sketches , progressive reports of major dams of same time are available. Except some crude photos showing over all picture of construction and M.V travelling in a boat to inspect the dam no valuable on site information is available. M.V gave call to engineers in conferences to gain expertancy in their respective fields and to acquire knowledge. We do not know whether the design documents of Kannambadi dam were made available in the libraries of Engineering association or not. From available information it is clear that there were no technical discussions among engineers regarding Kannambadi dam. H.D Rice who was active in Marikanive project has brought the history of dam construction. M.V while drawing the attention to it and called other engineers to come forward for such work .

In final, the following are the elusive reports on Kannambadi which I failed to trace and somebody lucky may be successful :

(1) Kaveri Resevoir Project' 1911- Public Works Department, Govt. Of Mysore ,

(2) Kaveri Resevoir Project in Mysore: Revised edition 1934- Public Works Department, Govt. Of Mysore ,

(3) Note On Krishnaraja Sagar Works –N Sarabhoja , paper No. 9 , Silver Jubilee Publications , Mysore Engineers Association , 1932.

(4) Flood Absorption in Krishnaraja Sagara , Hydraulic Research Station , Report ending with the year 1946.

3.6 Kaveri Dispute

By the end of 19th century princely Myore state started to expand its irrigated area by desilting the old tanks and construction of new tanks. Madras government which was observing these activities across Kaveri and its tributaries wrote a letter to Indian government that the irrigation interests of Madras region would be jeopordised by that. As the result of this a meeting between Mysore and Madras engineers was held at Ooty on 10/5/1890. A note prepared by Diwan Sheshadri Iyer of Mysore state was placed before the sitting team in which it was clearly stated that without effecting the interest of Madras state , Mysore state has every right to use the water which flows within its teriroty. Madras contested this stand and argued that the its right over water shall not be isolated to irrigation on Kaveri river but to all water which flows within its territory. Further it argued that Mysore state's statement 'without effecting Madras state' does not have any merit as it does not have any definite parameter. Against to this Mysore state forced the Indian government to formulate guide lines for water sharing of rivers. After multiple letter correspondences on 18/2/1892 an agreement titled ' Rules Defining The Limits Within Which No New irrigation Works Are To Be Constructed By The

Mysore State Without Previous Reference To The Madras Government' came out.

The highlights of the agreement were : (1) Mysore state shall not construct any structure to store water on downstream of Honnali bridge in Tungabhadra basin , downstream of Ramaswamy dam in Kaveri river basin and below Ramapura dam in Kabini river valley. (2) Without providing full technical information to Madras government, Mysore state shall not take up restoration of any existing tank or construction of new reservoir. (3) Unless the existing traditional rights over water usage , quantity , area of Madras are affected , it shall not object to any project taken up by Mysore state. Each project shall be discussed separately between the two states for their rightful shares. (4) If there is no consensus between the states then both shall refer their arguments to the third party. As per this agreement Mysore state was forced to take the permission of Madras state for 15 main projects. In this agreement even though (1) and (2 seems to partisan towards Madras , Mysore engineers through points (3) & (4) checked the control of Madras state over Mysore state. All the future disputes on Kaveri water sharing hinged on these points.

In 1910 , when M.V was Chief engineer of Mysore state , due to various developments construction of a large capacity reservoir across Kaveri river became inevitable culminating in Kannambadi project. As per 1892 agreement M.V wrote a note to Madras government on 15/10/1910 informing about the proposed project. In this note available water below the Kannambadi dam after completion and that flows in madras region during normal rainfall year were enumerated. The main points of M.V note were as listed below.

(1) During normal rainfall year major portion of water flows into the sea. This water will be stored in Kannambadi reservoir which will be let into the river after power production. By doing so even after rainy season Madras region will get sufficient water. Thus Tanjore belt farmers of Madras region can get water without any

cost and sacrifice. Kannambadi reservoir is win-win project for both the states.

(2) Constructing small dam across Kaveri is economically not viable, difficult to maintain as it loses the capacity by silting in a few years. Due to the topography of the land near the location of proposed dam it is not possible to fix sluices and supply water to irrigation canals below 18.3 M (60') level from river bed. By constructing high dam and storing large quantity of water only it is possible to provide water to large area which is reeling under famine. Therefore 42.7 M (145') high dam with storage capacity of 1.22 BCM (43 TMC) is suitable.

(3) By constructing Kannambadi dam only 0.879 BCM (31 TMC) of water will be deficient to Madras state which only 10 % of the total yield of the river. Hence there will be no effect on the quantity of flow to Madras area.

(4) By constructing Kannambadi dam the flow to Madras state will be reduced during June-July months and this can be resolved among the states with further discussions and alternate methods.

Additional data was provided by M.V to support the claim that there will be no net effect on quantity of water that flows into Madras state.

After this letter correspondences between two states continued. A meeting was held between chief engineers of Mysore & Madras states including Secretary C.A Smith. The main objections raised by Madras government during this meeting are as below listed.

(1) The irrigated area under Kaveri achcut in Madras state is more than 10 lakh acres.

(2) The flow in Kaveri river fluctuates each year. Since from some years the flow is maintained at 2.135 M (7') at Mukkombu. This flow is equivalent to 0.066 BCM (2.3 TMC) per day.

(3) Storing water and diverting it on upstream side is nothing but snatching away of the rights of Madras state.

(4) When the water level near Mukkombu goes below 2.135 M (7') , no water shall be stored in Kannambadi reservoir. If this condition is followed then as per the available rainfall records , out of 20 years Kannambadi will not fill in 3 years.

Madras government further argued that in next stage water level less than 2.135 M (7') will have detrimental effects on irrigation in Tanjore delta area. Therefore as per 1892 agreement Mysore state cannot build the Kannambadi river of the proposed size and capacity. This was the stage at which Madras & Mysore state confronted each other with technical facts and statistical data. The remaining decision was political which was beyond M.V's scope , capacity and limits.

Along with the letter written by Mysore state on 27/3/1911 a technical note for the revised project was attached. The highlights of the notes were : (1) Permission shall be granted immediately to build 24.4 M (80') high dam (2) Before sanctioning the permission to construct the Kannambadi dam to full height Indian government shall obtain the data from Madras state regarding the area irrigated , water utilized for previous 20 years (3) Madras government may build new reservoirs and claim it as traditional right. To check this permission shall not be given to construct any new reservoir/dam. Among these four points (1) was the request. This was the middle path which was emerged from the demands of John Taylor company and the immediate actions to be taken for improvement of the economic condition of the state and concern to provide irrigation facilities to for farmers distressed under famines. Point (2) was to check technically the advances of Madras. The point (3) was equivalent to filing caveat to the court which questioned the validity of constructing Mettur dam across Kaveri in Madras state.

General Sir John Benton through letter dated 12/5/1911 replied to the revised project of Mysore state. The highlights of the reply were :

(1) If the flow is less than that agreed in 1894 , the interests of Madras state are at risk.

(2) The flow in Kaveri river shall be maintained as argued by Madras state.

Through letter dated 7/7/1911 Diwan of Mysore requested to accord approval for 24.4 M (80') high dam of capacity 0.32 BCM (11.3TMC) immediately. Sir John Benton answered to the letter on 28/7/1911 along with some notes. The main points of the note were (1) The interests of Madras state shall be safe guarded (2) The Mysore government has not specified any guidelines to assure flow from Kannambadi. These shall be mutually discussed between two states and to be finalized. (3) As per the Table proposed by Col. Ellis , a dam not exceeding 0.32 BCM (11.03 TMC) can be constructed and its operation shall not be detrimental to Madras state.

Answering to this , Diwan of Mysore wrote a letter to Indian government on 31/8/1911 requesting to advice Madras government to allow construction of 24.4 M (80') high dam in first stage. Through its reply on 23/9/1911 Madras government clarified that it has no objection for 24.4 M (80') dam. But it also observed that Mysore state has designed the foundation for 42.7 M high dam. Therefore Mysore government shall provide indemnity to Madras state that it will not will not raise the dam to 42.7 M (140') in future. To this Maharaja of Mysore replied through his Diwan and assured that (1) the total irrigated area under Kannambadi does not exceed 25000 acres (2) Such assurance will be given to the full satisfaction of Madras state. (3) Water flow in the river will be maintained as acceptable to Madras state (4) Dam will not be raised since the foundation are support taller dam. It was part of the tactics of Mysore government to accept for 24.4 M (80') high dam whereas the foundations were designed for 42.7 M (140')

high dam. Through letter dated 8/10/1911 the approval was given for 24.4 M (80') high dam. Immediately construction was started.

In future days many rounds of talks took place between Madras & Mysore governments regarding the height of dam , the guidelines to assure flow in river etc., and no consensus was made. Therefore government of India suggested both the parties to resolve their issues before a Tribunal as per agreement of 1892. Mysore government accepted this without any refrain but with a condition that the decision of the tribunal is not final and Mysore state reserves the right to question its decision by placing the facts in front of Indian government. Indian government accepted this condition. As a result of this tribunal was set under Sir H.D Griffin , the judge of Allahabad court and Nethersole, Irrigation commissioner of India. The hearing started on 16/7/1913 in Ooty. Nethersole was a civil engineer and had the complete technical knowledge to understand the argument of both parties and advise H.D Griffin. In this trial Mysore government tried to free itself from clutches of 1892 agreement by questioning the right of use, the quantity of water to be released into the river , the height of Kannambadi dam , its control and the time tenure of judgment of the tribunal. The main arguments put forward by Mysore government are listed below :

(1) Mysore government agrees to maintain 1.83 M (6') water level near Mukkombu to safeguard the interests of Madras state. But this was raised to 2.135 M (7') in 1892 agreement. This modification brought twenty years back does not constitute to traditional right of use.

(2) Mukkombu anicut was restored during 1899-18902. Therefore there is no validity for the claims of right of use.

(3) Times immemorial Kaveri river underwent fluctuations of flow. Madras state has accepted its right of use within this uncertainty. It is wrong on the part of Madras government demanding for fixed amount of water on the sole reason that Mysore state is

constructing a dam. Hence fluctuations of flow shall also be taken into account.

(4) Madras government is demanding the water in summer season also. But there is no consensus on the quantity of water in the river during summer.

(5) Does Madras state really have summer crops ? If so, what are the limits of right of use ?

(6) Why the flow in river not to be fixed month wise ?

The arguments (3) , (4) & (5) made by Mysore state were technical and acted against the circular argument of Madras state.

The opinion expressed by Nethersole after hearing both the parties are as below :

(1) It has been found from records that during 1882-1892 the maximum area was under irrigation in Madras state. This comes under right of use.

(2) Madras government has failed in establishing why the minimum flow depth of 2.135 M (7') has to be maintained.

(3) There is no relation between the depth of flow of 2.135 M (7') and the area irrigated as argued by Madras government.

(4) Madras government has a proposal to construct a large dam near Mettur. In project report it has been established that even after construction of such a dam the water level near Mukkombu will be 1.855 M (6'1") in months of July-August. Therefore Madras government has accepted that after its right of use if the depth of flow is more than 1.855 M (6'1") near Mukkombu then the water is wasted and flows to the sea. Therefore it is sufficient on part of Mysore state to maintain 1.98 M (6'9") depth of flow near Mukkombu barrage.

(5) No restriction can be made on Mysore state to use water in excess of 2.00 M (6'9")

(6) Madras government in its project report stated that even after flow of 1.855 M (6'1") depth of water near Mukkombu , there will be sufficient water to store in Mettur dam and to bring 350000 acres of land under irrigation. Therefore madras has accepted that 1.855 M (6'1") flow is sufficient for its right of use.

(7) The attitude of Madras is that it is the sole responsibility of Mysore government to assure 1.98 M (6'6") flow near Mukkombu. But Madras government has its own responsibility to maintain that level through Bhavani , Suvarnamukhi and other rivers which are tributaries of Kaveri.

(8) Even though it is very difficult to decide the contribution of both the states to Kaveri from available data , it can be estimated that Kannambadi catchment contributes 62.5 % to Kaveri river.

(9) Even during the minimum rainfall years also after catering the right of use of Madras state water flows to the sea.

(10) Madras government has argued that if 42.7 M (140') high dam is built , it will not fill for 3 years in duration of 20 years. This is not any way concerned with water sharing. After assuring the specified flow , Madras government does not have any right to question the economic viability of Mysore state project.

On the basis of expert opinion of Nethersole , through the final judgement delivered on 12/5/1914 , the tribunal came to the conclusion that by raising the Kannambadi dam height from 24.4 M (80') to 42.7 M (140') the traditional rights of Madras state are not affected and allowed Mysore state to construct dam with net capacity of 1.049 BCM (37 TMC) .

Questioning the judgment given by tribunal under H.D Griffith Madras government wrote a letter on 21/4/1915 to Secretary , Public Works Department , Government of India. Counter to this in

a letter written to secretary Indian Government , Mysore government argued that in the judgment given on 6/7/1915 by H.D Griffith , it has become obligatory for it to assure specific quantity of water flow in the river (25.53 Cumecs=900 Cusecs) even in summer. The actual flow during summer is less than 1/10 of the specified quantity. Therefore it is not possible to implement the judgment and require modifications in it. Replying to Madras governments letter on 30/3/1916 , Secretary , Public works Department clarified that since the tribunal has taken all the aspects in to consideration , there is no way to change its judgment. Replying to Mysore state's concerns Secretary , Indian government informed that if Mysore government is not satisfied with the judgment it can resolve it through discussions/negotiations with Madras government or can appear before one more tribunal.

After this Mysore and Madras governments agreed to resolve the issues among themselves without any third party involvement and informed this to irrigation secretary on 26/3/1920. It was decided that the discussions shall only be on technical issues. The meeting was represented by W.J Howl , chief engineer , Irrigation department , Madras state and S.Kadambi , chief engineer Mysore state . This meeting and consequent discussions culminated in formulating water sharing criterion. In this agreement the future projects were also considered. On 18/2/1924 both the parties signed the agreement. By this the third stage of struggle for water by Mysore state was over.

It is not clear what was the role of M.V in Kaveri water sharing and raising the Kannambadi dam height . By end of 19th century Mysore state was claiming its natural right over waters of Kaveri , Tungabhadra and Pennar. By 1801 Marikanive project was thought of. During 1885-90 Mysore state was very eager to take up Marikanive project which was objected by Madras state. After 1892 agreement , Mysore engineers through their powerful arguments were able to obtain permission to construct Marikanive dam by 1894. British government had a plot to interfere and

influence in internal matters of Mysore state by appointing Madrasi Iyer Brahmins as Diwans. After Sheshadri Iyer became Diwan of Mysore , British did not succeed in curtailing the rights of Mysore state over its waters. The tight grip on administration by Kempa Nanjamanni who was ruling on behalf of her minor son Nalvadi Krishna Raja Odeyar , the circumstantial pressures , the morality to safe guard the people whom he represents made Diwan Sheshadri Iyer to claim rights over water firmly. Mysore engineers were very critical about some technical aspects of 1892 agreement. Due to this it was not easy for Madras government to claim hegemony over water rights.

When Kannambadi proposal was made the water sharing dispute had reached to its peak. During such time M.V was appointed as chief engineer. M.V continued the tradition of Mysore engineers and fought for rightful share through technical data and arguments. Not only M.V , any engineer in that position would have done it. It was inevitable also. After M.V had meeting with Madras chief engineer , through rainfall data it was argued that Kannambadi will not receive full water for 3 years out of 20 years. Then there was a chance for M.V to raise a fundamental question. Does Mysore government has to assure same quantity of water to Madras during years of distress also ? If so is there not a blow to natural justice by abiding only Mysore government to brunt of natural distresses ? If such questions were raised by M.V then the tribunal would have been forced to find answers to the relevant questions such as what is 'normal rain fall ' , which is the 'distress year' , what are the guidelines for water sharing during distress etc., By these questions 1913 H.D Griffith tribunal would have forced to find solutions for those issues. If we observe that all the struggles that rocked after 1924 for water sharing between Mysore/Karnataka and Tamilnadu were during distressed years only. Therefore it can be said that M.V failed to visualise the complex water sharing issues of the future.

In Karnataka it is widely propagated that M.V took bold decision to lay foundation for 42.7 M (140') high dam instead of 24.4 M dam.

Therefore everybody in Karnataka shall be grateful to him for his bold and visionary stand. But the facts speak the other way. There is no proof/documents to prove that M.V took such decision. The Bernard Dawes report had proposal for such high dam and cost of such project was well known among administrators. Maharaja was determined to take up such a project before M.V's arrival. He knew the storage capacities and the difference of cost between 24.4 M (80') & 42.7 M (140') dams. The decision to lay foundation for 42.7 M (140') even when appearing before Tribunal was purely political and nothing to do with M.V . Even in independent India various states often take such decisions before permissions are granted and with lack of funds. Foundations for Alamatti dam was laid for maximum storage level of 524.256 even before the tribunal gave its judgment. The governments take ultimate decisions in such matters relying of the expert advice of engineers , policy makers considering the future benefits. Such group decisions cannot be attributed to a single person.

3.7 Bhadravati Iron Works (BIW)

To understand the back ground of establishment of Bhadravati Iron Works , the role of M.V , the success and failures of the project one has to know the conditions of India at that time. By second half of the 19th century there was great shift Indians mentality in evaluating themselves , British and the outside world. The achievements of Indians and their thinking looked dull against the technical advancement of British seeding the inferiority complex in Indian minds. To overcome such inferiority complex persons like Swami Vivekananda relied on the superiority of Hindu religion. Indians had their own understanding of Europeans, their society and culture. The English educated upper class Indians believed that development is encapsulated in scientific advancement , technical expertency and by gaining hold in scientific and technical fields through which the Indians can overcome the inferiority complex which haunts them. Japan an asian eastern country which was developed like Europe was such a possible model to them. The

Diwans of native states , especially Brahmin Diwans of Mysore state staunchly held such views which were supported by Maharaja.

By 1881 Diwans of Mysore came to the conclusion that without industrialization there is no progress. As a result of this by the beginning of 20th century Hydroelectric and irrigation projects were either under completion or implementation stages. In 1890 Diwan Sheshadri Iyer believed that no industry like Iron manufacturing can advance Mysore state. Since iron is the basic material for any industry , by producing it manufacturing industry could be revolutionized through which one can encounter British in their own field was the thinking. From beginning Mysore Diwans moved in the direction of industrialization. M.V who became chief engineer in 1909 and Diwan in 1912 continued tradition and declared that by seeing the other countries we must decide the path in which we have to go. M.V saw industrialization as one of the way to bring confidence in Indians.

By 1896 some visionaries suggested to extract iron from abundant iron ore deposits of Bababudan giri. A geologist was sent to Turin , Italy to study the feasibility of such possibility. In his report it was noted that since Coke and Coal are not available in Mysore state , importing them from outside is costly which is the main hindrance to the proposal. By 1909 British were aware of the awakening of 'Swadeshi Consciousness' in Indians. They thought that this new awakening could be countered by taking native princes and kings into confidence by assuring them more autonomy and gain the confidence of common people by not obstructing the initiative taken by kings to move in direction of industrialization. The situation in Mysore state was very encouraging to start new industries.

M.V as a civil engineer had experience in water supply , irrigation , construction etc., and not in manufacturing. Therefore he was dependent on others to establish iron manufacturing unit. Therefore the role of M.V was like a technical manager on investor

side rather than the subject expert. This is very clear when we see the conceptualization , construction , maintenance of BIW .

M.V always saw forests of western Ghats as sources for fuel. This is evident in the speech made by him 0n 11/8/1913 during inauguration of DG pump set installed in the field of progressive farmer Balappa of Harihar. The excerpts of M.V speech ran thus : 'This pump will be worked by oil engine. The oil is the favorite fuel at present for small installations , but dependence on imported fuel should be avoided as far as possible, because then the commercial success of our large irrigation installations will be at the mercy of high prices and foreign markets. Steam engines are also not economical for operating small pumps. One remedy seems to be extend the use of gas engines like one working in Bangalore tannery. It should be possible, at no distant date , to manufacture the requisite supply of charcoal from the redundant wood supply of our dense Malnad forests'. For M.V it was attractive to obtain charcoal from wood from forests of western Ghats. During travel in Europe, in Sweden M.V had seen the manufacturing of steel using charcoal obtained from burring wood from the forest. M.V was thinking in the same line.

Tata Iron & Steel Co., (TISCO) established the iron factory based on modern technology in India in 1912 , near Sakkhi village , on the confluence of rivers Suvarnarekha and Kharkai , in present day Jharkhand state. This was near to the port and was suitable place to import charcoal and export iron through sea route. Such advantage was not there for Mysore state. The area with rich iron ore was in inlands and there were no suitable routes to transport raw and finished goods. The lack of charcoal sources in the state was the other draw back. With all these draw backs M.V proposed iron factory near Benkipura (Bhadravati) of Shivamogga district. Neither M.V nor other engineers of Mysore state had iota of knowledge on iron manufacturing. Therefore in 1915 , Mysore state requested Charles Perin , private consultant to TISCO to prepare a feasibility report for the project. Charles Perin in his report recorded that even though Mysore state does not have

charcoal resources , it is possible to manufacture it from the wood available in dense forests of Malenad region. Benkipura (Bhadravati) was identified as the suitable place to establish the factory as it is near to forest, abundant water sources and iron ore. In continuation of this on 4/6/1918 , Mysore state appointed TISCO as its managers.

Often M.V was ruled over by perceptions rather than hard facts. Others who identified the drawbacks of the project opposed its implementation. The main objections were : (1) The data provided by Charles Perin is not reliable. (2) Due to ongoing World war the cost of the project will exceeds the estimates. (3) The Money spent on installation of furnaces before laying the railway line to transport the material will be dead investment. (4) By supplying the wood from forest freely the revenue that generated from selling of timber will be lost (5) Even though TISCO is not the underwriter to any uncertainties , risks that may arise in the execution of the project assurance has been given to pay commission on construction cost and 25 % on future profits. In prevailing practices the appointed managers have the responsibility to mobilize investment , promote products in the initial stages , introduce new markets and partner in risks. TISCO does not have any such responsibilities. (6) The technology which converts wood to charcoal is not clear. (7) There is no clear information on the quantity, quality and market for Acetate which is by product in converting wood to charcoal. (8) The iron manufacturing using charcoal from wood is not suitable technology which will be absolate soon in coming years. (9) The cost of charcoal production , ore mining and transportation estimated are at low rates. (10) There is no information on the quality of iron manufactured. [24]

[24] Extracing iron from ore by using charcoal obtained through wood burning is an old technique. Archeologists have argued that by by 500 C.E African forests were destroyed due to this technique. Before advent of industrial revolution in Europe , iron was extracted from ore using wood charcoal. By 1540 there was an outcry in England that the forests are being destroyed by iron manufacture. In 17-18 centuries iron production of England reached loawest point due to deficient

The doubts raised by skeptic opponents on the feasibility of the project started to become realities one after the other. The cost of equipment sky rocketed due to world war. The customers identified by Charles Perin in his report were more on assumptions than the reality and failed in finding guaranteed purchasers. Then, M.V started to pressurize Maharaja to invest money citing the reasons. The main argument of M.V was , to complete the project 5-6 years are required and by that time world war would be ended with higher demand for iron which will bring back the investment with higher returns. Initially we must be ready to face the loses. The importance of the project ultimately answers all these adversaries. Bowing to these arguments and pressure Maharaja released 1.2 crores. Even though the uncertainties were known before the start of the project , Mysore state proceeded. We do not know whether M.V knew the drawbacks and uncertainties in the Charles Perin project or even after knowing also he pushed the project on own urge of starting big projects.

Due to uncertainties the project cost was pushed to 114 lakhs from initial 64 lakhs. There was no market for Bhadravati iron. TISCO and Indian Steel Co. we're supplying pig iron to factories in north India. There was no industry in south India which would have used pig iron manufactured at Bhadravati factory. Transportation cost of TISCO and Indian Steel Co which were established near ports were much lower when compared to BIW. Since there was no port near the factory it was not possible to export to other countries. Thus the cost of Bhadravati iron was higher than others. For next 15 years BIW suffered with continuous losses which rose to 2.5 crores by 1930-which was equal to the total cost of Kannambadi project.

---

supply of wood. Russia and Sweeden which had large forest area could only possible to manufacture iron from wood charcoal. Therefore by the beginning of 18th century in England methods were developed to extract iron using coke, which in future became the standard material in next 50 years.

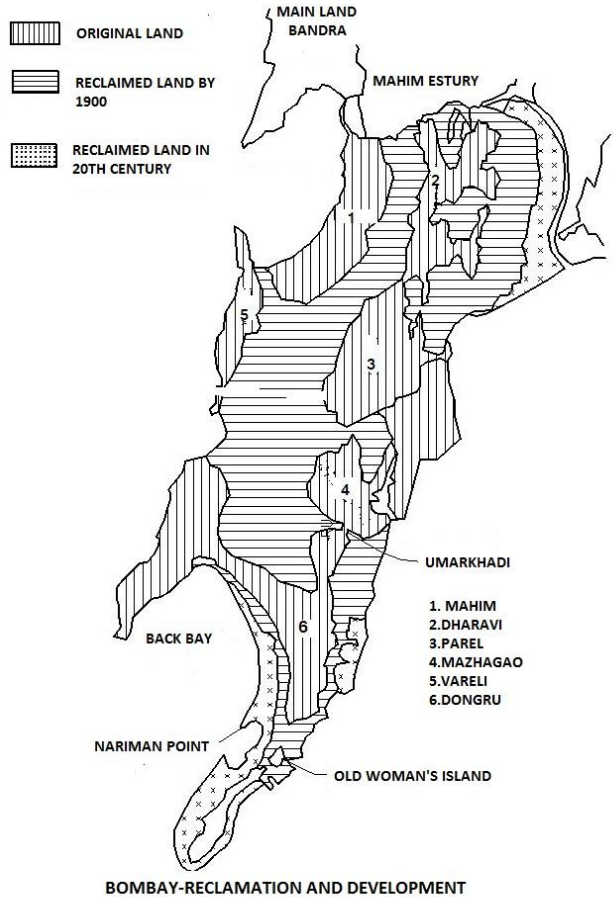
The technology to manufacture iron from the charcoal obtained from distractive burning of wood was suitable to countries like Sweden and Brazil where the density of population was very low when compared to the extent of natural forest area. Mysore was not such a state. Mysore state failed in afforestation of the of the area in which wood was procured. The technology proposed by Charles Perin became obsolete in few years. Various other methods were developed to manufacture Acetate which finally gave death blow to crude acetate obtained as by product in BIW.

Any project including irrigation must be feasible to bring back the investment made on it with prevailing rates of interest . To achieve this all the pros and cons shall be investigated thoroughly before taking up the project was the policy of British government as well as Europeans. For this (Benefit/Cost) concept was introduced. M.V was trained by British under same policy. As Executive Engineer of Mutha & Nira canal M.V had forcibly argued that the water stored in the reservoir must bring back its investment with interest. Otherwise it is very difficult to take up any project. M.V threw his own policies to winds in case of BIW . Without considering the risks involved such as uncertain technology which would become obsolete in near future, undefined markets , the possible competition in market , uncertainty in machine and equipment supply , inflammation in cost due to world war , M.V single mindedly pushed the project forward. There was no doubt that the project which had losses in its conception, in seed itself, would fail miserably. M.V tried hard to rescue this project which was an engineering disaster and financial failure. Some have pictured M.V as a hero, captain who struggles to rescue the sinking ship. But facts pinpoint to the fact that M.V was chief manager of the project who conceived it wrongly and struggled to bring into correct course without success. The complete objective study of the project can throw some more light on this.

By the grace of Maharaja factory survived. M.V felt that the confidence which it brings to the Indians to face British in their own field will outweigh its failures. BIW was not seen as an enterprise

but as an adventure. In this view M.K Gandhi who was neither an entrepreneur nor a technocrat praised M.V in unequivocal voice. M.V was failed by his own project which was born from incomplete planning , unsuitable technology and unclear business frontiers. Therefore BIW is one of the failed dreams of M.V

3.8 Investigation Of The Bombay Back Bay Reclamation Scam



BOMBAY-RECLAMATION AND DEVELOPMENT

The present Mumbai city is built on seven small islands named Colaba, Old Woman's Island, Bombayam , Mazhagao , Mahim , Vareli and Parel. Shallow , marshy land existed between these islands which was called back bay. Wall can be built at and between boundaries of such lands to prevent entering of sea water. By dredging the soil in the sea bed can be filled into the land between walls. After consolidating the soil with equipment land can be utilized for housing , urban activities , transportation etc., Converting useless marshy area into useful land for urban activities is called reclamation. The project to reclaim the land between islands was termed as Bombay back bay Reclamation. In 1710 Portuguese stated to reclaim the land in small scale. After British acquiring these islands they started to reclaim them on bigger scales. The first phase of reclamation work was stared , progressed and were completed in 1784, 1803 and 1845. After this reclamation progressed in multiple stages. (Fig : Bombay Islands & Back Bay Reclamation)

In 1912, Bombay government proposed back bay reclamation project and appointed Kidd , the partner of M/S Lowther & Kidd Co., to prepare a feasibility report. Kidd collected the soil samples through boring , conducted engineering tests and submitted the report. By filling the marshy land between islands 1145 Acres of land can be reclaimed for public use and on east of Colaba 124 acres can be reclaimed for military. The total estimated cost of reclamation would be Rs. 2.43 crores at cost of Rs. 106 to 125 per Sq.yard. The market value of such reclaimed land would be multiple times that of the cost incurred. These were the highlights of Kidd report. After this there were no further discussion and meanwhile world war started.

In 1918 Governor of Bombay Lord Wilingdon retired and Sir George Lloyd was appointed to his position. After George Lloyd assuming the office , the reclamation project started to breathe once again. For George Lloyd reclamation project was an opportunity to resolve many haunting problems of Bombay . He wanted to relieve the pressure on upper rich class residential areas from labor class

by selling the reclaimed land at good prices bringing profit to government. Indian state secretary Lord Montagu had expressed his concerns about shortage of residential area in Bombay. George Lloyd had met Lord Montagu in London before coming to Bombay and did explain his reclamation plans.

As soon as Lord Montegu came to Bombay George Lloyd wrote a letter to him informing that Bombay Development Trust do not have any land for developmental activities as it failed in evacuating illegally settled Indians in old bazar area , in temple premises and public areas . He also argued that the house owners does not want new areas to develop as they bring down the rentals. If the people are evacuated forcibly then the nationalists who are demanding for 'Swaraj' will raise up. Therefore reclamation is the only practical solution. In 1920 , in Bombay legislature assembly George Lloyd demanded to establish Development Directorate for providing civic amenities like water supply , sewerage , schools , roads , houses etc., By doing so , George Lloyd thought that the Indian members in Bombay Municipal Council who are not trust worthy , who pounce on and often upon British government can be kept out of Reclamation project.

To know the feasibility of Reclamation project Bombay Development Committee invited opinions of citizens , officials, traders, industrialist and citizens. By collecting such opinion it was concluded that there is necessity of large land for public utility. But by seeing the cost of reclamation Bombay government refrained and was at the stage of backing out of it. In 1919 George Lloyd had sent a telegram to Secretary Montegu , pressing for the advice of expert engineers. He also informed that he was going to appoint Sir George Buchanan , who served as Municipal Board member before coming to Bombay , who had experience in reclamation works in Basra in Iraq and Rangoon in Burma. Finally it was agreed that Buchanan shall study the report submitted by Kidd and give suggestions regarding the feasibility of the work and Bombay government shall consider it as final.

After coming to Bombay , Buchanan visited the site and started Meek & Buchanan Co., to study the methods to implement Kidd report , decide the type of dredger to be used , to prepare Bill of Quantities and the cost involved etc., After studying the report of 1912 , prepared by Lowther Kidd & co. Buchanan gave his report in September,1919. In this report the methods proposed , the technical details given by Kidd were accepted. But it was highlighted that the estimate of 2.43 Crore made by Kidd was higher and the same work would have been completed at 2.41 crore in 1912, which works out to be 3.68 Crores in 1919. Meik & Buchanan co. was ready to take up this work. In 1912 Bombay government was afraid of cost and backed down from taking the project. Then questions were raised in some circles that if a private company can make profit why not Bombay government. As per the Buchanan report Bombay government would profit 20 lakh dollars from reclamation. Bombay government which was blind in front of this proposed profit , without going into details placed the report in front of Bombay Legislature committee and approval was accorded in haste in May, 1920. Through this M/S Meik & Buchanan Co., was appointed as consulting engineers. It was decided that Bombay government will take up the work under the guidance of Buchanan.

Stone quarry was started 32 KM away from Kandivali to obtain stone required for construction of retaining wall from Colaba to Marina. The dredger was named as Sir George Lloyd. The dredger has the challenge of filling 2.5 Crore Cubic yard of soil into marsh. In 1924, W.R.David published an article on this gigantic work. The photo of large dredger, the beautiful engineering drawings published along with this enkindled the dream of solving the problems of homes and public places. In this dream Greece Inn of London and Oxford College were reincarnated. It was projected as the beautiful , hygienic place with magnificent buildings with good air and light , away from sweating smell of labor class.

By end of 1922 , backfilling work started. For next 18 months nobody asked or checked the quantity back filled by the dredger. In July , 1924 the efficiency of dredger was measured. In his report

Buchanan had considered 2000 Cu.yard of dredging in an hour. But dredger never was able to lift more than 1020 Cu.yard in an hour. The inspections done in next year revealed that more than 900000 Cu. Yard of dredged soil escaped out of the openings in the retaining wall. Immediately after this news leaked , the doubts about the feasibility and success of reclamation project were raised. Also , by this time world war ended bringing down the real estate prices. The validity of Bukhanan report was questioned.

'Bombay Chronicle' which was started by Indian nationalist of Irish origin B.G Hornian published the scams of the reclamation project one after the other , bringing the suspicion in the mind of common man about the intentions of British. K.F. Nariman , the member of Bombay Legislative Assembly took every7 opportunity to raise the issue in session. K.F.Nariman charged that without giving proper information to the public Bombay government has taken up such large project to cheat the people. In 1924 , Nariman, called for an enquiry of the whole project. In response to that Bombay government constituted advisory board and invited Nariman as its member. Nariman rejected the offer citing that when the working of Government is not known what is the point in becoming member in its committee.

The report given by Advisory Committee has two parts. In the report of the majority it was recorded that Buchanan had assured to reclaim 1145 acres of land in 5 years at cost of 3.6 crores. But for that work the actual amount required is 8.47 crores in extended time period of 20years. Therefore Buchanan is solely responsible for the failure. But in the minority report of Indian members , government was blamed for taking up the project without bringing to the legislative council. It also criticized that government has created Lloyd lake to breed mosquitos instead of reclamation. K.F. Nariman accepting these two reports made allegation that rumors are going on that sufficient corruption had taken place at official levels. Sir Lawlew Hepper rejecting the allegations made by K.F.Nariman rebuked him that yellow eye sees yellow everywhere. This took ugly turn and started new war of words and came to an

end after Lates apologizing K. F.Nariman. Not satisfied by this K.F.Nariman continued his tirade against the government through series of articles in Bombay Chronical with catch titles like ' Lloyds Mistakes' , 'Black Bay' , 'Soiled back Bay' , 'Bay sludge' etc.,

The articles published in Bombay Chronicle one after the other shook the confidence of Bombay government. Buchanan who was enraged by the majority report of advisory committee wrote a letter to Lord Burkenhead , Secretary to government of India , demanding to constitute truth finding committee. As a result of this in June , 1926 Back bay Enquiry Committee was constituted under the Chief justice of Allahabad court Sir Grimwood Mears along with members M.V Frederick Hopkinson, S.B Billimoria and R.B Ewbank. Since Bukahanen was very arrogant engineer the representatives of Bombay and Indian government refrained to question him on face regarding the estimate made by him. If you have any doubts about my professional efficiency constitute an enquiry committee comprising of engineers equal to my capacity was the arrogant challenges posed by Buchanan to the committee in 1926. M.V who was appointed as the head of technical committee took the challenge of Buchanan. After completing enquiry in India , committee travelled to London to enquire Buchanan. He made the committee to wait for him for 12 days. Appearing before the technical committee headed by M.V he replied that he was not part of the scandal but the witness to understand it.

After detail enquiry report came out in February , 1927,. The highlights of the committee report were :

(1) There are lacunas in the report prepared by Buchanan. The estimate has not been done properly. Therefore the real cost is many times more than the estimated/proposed cost.

(2) Dredging activity has failed miserably.

(3) The sequence of construction of retaining wall is wrong.

(4) Execution team constituted is not correct – the responsibility of each member is not clearly indicated.

On the first three technical issues M.V questioned Buchanan severely.

The scope of work both in Kidd and Buchanan reports are same. But the cost estimated by Buchanan is wrong. The wrong unit rates considered by Buchanan is the reason for this. The revised estimated cost given by Buchanan in 1919 is only 10 % higher than that considered by Kidd in 1912. But the rate of raw materials and labor required for reclamation work increased by 275 % and 100 % during this period. Even if the improvement in exchange value of rupees to Pound is considered , the unit rates considered by Buchanan are far behind. This was the firm conclusion of M.V. For this Buchanan argued that that it was his rate list but he was not the persons to take decision on it. The enquiry committee felt that Buchanan may not have considered low rates purposely but the Bombay and Indian governments failed completely in recognizing it.

On the estimation of dredging capacity of the machine at 2000 Cu.Yard /hour Buchanan estimated 5 years for reclamation work. But in practice its capacity never crossed 1020 Cu. Yard/hour. In his report Kidd has recorded the dredge as 'firm and non soft'. Buchanan has changed it to 'hard. The soil recognized and descriptions given by Kidd and Buchanen were different. This was not recognized by the government engineers which resulted in the lower work turn out. It is wrong on part of Buchanan to consider a machine with a capacity of 2000 Cu.yard/hour works with same efficiency under all circumstances. This is one of the major reasons for the failure of the project. This was the second observation made by M.V. Buchanen did not agree to this and contested that soft clay , stiff clay , firm clay all have same density . Therefore these soil was recognized as 'hard clay'. This explanation was not accepted by technical committee.

M/S Simon & Co. who were the suppliers of the dredger considered soft clay. But George Lloyd argued that M/S Simon & Co., has failed in supplying correct dredger. But the technical brochure provided by M/S Simon & Co. had a technical note that the supplied machine has its capacity in soft clay and its real capacity will be known by actual use only. Mac Murray who represented M/S Simon Co. argued that the machines are manufactured considering particular type of soil. For that company had considered soft clay. If different soil is encountered in fields accordingly its capacity will change. There is nothing special in it and this point does not have any technical merit to discuss.

M.V had questioned Buchanen , why he himself did not check the capacity of dredger. For that Buchanen answered sarcastically that the enquiry committee is discussing only on capacity of the dredger . Is it possible to reject a machine like dredger after field test ?. For argument sake during testing dredger may actually achieve 2000 Cu.Yard capacity but this may not be possible on actual field work. If a dredger certified with capacity of 2000 Cu.yard does not achieve that it cannot be attributed solely on the machine. There may be many other technical reasons for that. No machine can work without man. Therefore the efficiency of the driver , the actual operating conditions shall also be considered. Thus the reply from Buchanen was sharp.

As part of reclamation 6.4KM retaining walls were required. Buchanen started this from two ends. Therefore the work was not completed on any side resulting on the dead investment. Due bad quality of work in filled dredged material has flown back to the sea incurring losses and with delay were the observations of the enquiry committee. Buchanen counter argued that material enough to complete the work with laid down specifications is available at port. It is possible to complete the work even today. If such thing has to happen government should take out its control over the project and contractors.

4.68 Crore was spent on reclamation work By 30/6/1926. Committee estimated additional 5.32 crores for completion of work and advised to complete the part of the original work as per the available funds. Since the project costs varied as per the individual approaches committee prepared two estimates. Buchanen did not agree for this and contested that committee and public are seeing reclamation work as a scandal. This shows lack of their far sightedness. Since real estate prices has gone down temporarily , the gap between project cost and returns from land sale seems to be large. But in future days this will not be the situation. There will be great demand for land bringing back the invested money in many folds.

George Buchanen was the consultant and leader of the reclamation work. He had the responsibility of bringing all the adversaries into line. But he did not discharge his duty correctly. This was the opinion of M.V. In contrast to this Buchanen defended himself that his role was restricted to provide consultacy/suggestions. Government had every right to override his advises.

The agreement executed between M/S Meek & Buchanen co. and Sir Lates Heptor, the head of Development Authority did not have cleary demarked , definite responsibilities for either parties. Therefore there was no clarity in the issues projected as scandals. Hence either parties were interpreting the agreement in their favor. Ultimately , enquiry committee came to the conclusion that as Buchanen argued , Sir Lales Heptor had the final authority to take appropriate decisions in which Bombay government has failed.

The final recommendation of the enquiry committee were : (1) If the works progressed in the current speed many years are required to complete the project. Therefore the area of reclamation shall be reduced , and within the available funds it shall be completed in next 3-4 years. (2) The Special Authority formed for reclamation work shall be dissolved.

At this juncture we can see the role of M.V. Buchanen was self centered , arrogant person. His demand to form the technical committee with members equal to his technical proficiency and stature. In the initial stages of the enquire Buchanen behavior was crude. M.V did not have the experience in reclamation work. For the work engaged to M.V there was no need of such direct experience. Because the reclamation work has only two major activities- construction of retaining wall and the mechanical work of backfilling the land with dredged material. Among these first one could be checked by any experienced civil engineer while the second one dependent on the efficiency of machine and its capacity. Beyond these the design and estimation issues which does not belong to the direct work were involved. These could have been reviewed by any experienced civil engineer. It was very evident through glance that the unit rates considered by Buchanen were wrong at half of the actual rates.

As member of enquiry committee M.V has queried Buchanen with clear technical points. Buchanen had complained that the questions posed by M.V were repetitive and he cannot answer them. M.V felt that the greatest mistake of Buchanen was considering very stiff soil as hard. For first instance, this point of M.V seems to correct. But it has its own limitations also. Companies manufacture machines on certain assumptions and situations. If they change the efficiency and capacity will also change. In large dredging work it cannot guaranteed that same type of soil is encountered everywhere. The samples took from sea bed by Kidd indicated the presence of stiff clay. But the spread and depth it was only a guess. Because in large area sample will be taken at selected points which may not represent the entire area. Even if Buchanen considered the soil as ‘Stiff’ instead of ‘hard’ and ordered for dredger to suit it , then also problem would not have solved. Because ‘stiff’ has to be defined clearly in engineering language through mechanical [properties of the soil. The geotechnical engineering branch of civil engineering was not advanced to classify the soil like that. After considering ‘stiff’ soil and finalizing the contract if soft soil was encountered at some

places then one would have identified the another scandal of considering all soil as 'stiff' instead of 'soft' .

The questions raised by M.V regarding unit rates were very sharp and it was not possible for Buchanen to answer. Therefore he argued that they were his rates and fixing up prevailing rates was the duty of the government. Finally , was there a scandal in Back bay Reclamation project. This has 'Yes' and 'No' , both answers. Construction of retaining wall from both ends cannot be seen as a mistake. Technical justifications can be given to that. The soil that escaped through retaining walls was equal to 50 days of work of the dredging machine , which compared to 5 year period works out to be meager 2.7 % . Such difference is not significant in large works like this. The unit rates considered by Buchanen made the project financially attractive. But there is no doubt it was impossible to get the reclaimed area of land as proposed in the project report. There is nothing of technical superiority in the work done by M.V as member of enquiry committee. But the attempts made by M.V to clip the wings of arrogant engineer like Buchanen must be appreciated.

Some other developments took place along with the enquiry committee trials. The British government wrongly hoped that after forming the enquiry committee the criticism of Nariman will cease. But Nariman attacked British government more fiercely than before. The attack was so severe that at one stage 'Bombay Chronicle ' was forced to clarify that it had no role in in it. British engineers filed defamation case against Nariman. After some days Nariman was elected to the legislative committee with great lead and once again became a big head ache for British government. The court took the defamation case for hearing and gave judgment on 27/1/1928. In judgment it was declared that Nariman fought to save public money. The charges made by him are symbolic and they shall not be considered as actually happened. There was other hidden dimension to the long struggle made by Nariman against Back bay Reclamation project. The trader class of Bombay city area which was enjoying higher earnings through rentals was afraid of

dip in rentals due to development of new areas. This class was indirectly supporting Nariman.[25]

In 1925, when proceedings of the enquiry committee were in progress Australian government took services of Buchanen. On behalf of M/S Meik & Buchanen co., Buchanen submitted report for development of land and sea transportation in 1927. In this report Buchanen noted that the capacity , efficiency , running and maintenance cost of dredgers cannot be relied upon. Many times their cost and time exceeds the estimate. Therefore Australian government shall establish separate Dredger Authority. This was the lesson learn by Buchanen in Bombay Back bay Reclamation project.

3.9 Orissa Floods And Mitigation

As part of British policy to mitigate the woes of famine by the end of 19th century tanks, dams and reservoirs were constructed in Orissa. During floods the back water in the reservoirs spread to far way areas beyond full reservoir limits. The farmers who were on the upstream reaches of the dam were very angry on other farmers who received water through government irrigation canals. These farmers constructed their own earthen bunds in the fields to save the flood water. Without any scientific method or guide lines many land lords constructed such earthen dams and canals to divert the water to their fields. Hundreds of such private earthen dams were spread across the catchment area of Vaitarani and Mahanadi. During floods these illegal earthen dams submerged additional area beyond reservoir. It was also known to engineers that by constructing sub canals it was possible to divert the flood water to other areas thereby reducing its devasting effects. Engineers feared that If done so , farmers do not purchase canal water but will start to wait for floods and may also resort to other ways to evade water

[25] In honour of K.F.Nariman in New Bomaby a place is named as 'nariman Point'.

taxes. This ultimately does not bring returns to the investment made on irrigation works.

In July , 1927 , Vaitarani river received huge floods. Due to this hundreds of earthen bunds , 'dams' , tanks breached , canals were destroyed , roads washed away. Bengal-Nagapur railway line was washed away in flood stalling all movement. The normal life was disrupted and people suffered as never before due to Vaitarani floods. Brahmani and Mahanadi rivers also swelled under heavy rains bringing still further damages. Three member committee was formed to find out the ways to mitigate the recurring flood miseries which haunted the delta region of Orissa. The members of the 'The Orissa Flood Committee' were Adams Williams , Chief Engineer of Bengal , D.J Haris the consultant engineer to Indian government and Ram Bahaddur Bishnu , retired official who served Bihar and Orissa while in service. This committee visited all the flood hit areas, collected the data , interviewed engineers as well as common people and submitted report titled 'The Report Of The Orissa Flood Committee' in 1928.

The observations made by the committee were very interesting. It was true that to safe guard against the famine hundreds of water storing tanks, bunds were built across the river. The each and every reservoir formed due to unscientifically built private 'dam' was the hindrance for the flow of river during floods. The reservoir formed by these bunds received the large quantity of silt bought by flood and were converted as silt trappers. In due course the river behind the reservoir area was silted reducing river width and depth. The silted river has lost the capacity to convey large quantity of water during heavy floods. Therefore during floods water crossed the bank limits , flowed over villages , agricultural lands, public and private properties. The committee observed that allowing flood water to flow in natural way was only the solution which would be achieved by removing all obstacles in form of 'dams' and 'bunds'. On Vaitarani and Brahmani rivers and their tributaries many small bunds and canals were constructed parallel to the river banks. Due to this there was no sufficient water way in

the river course to convey flood waters. If these bunds are removed the flood water will move naturally through larger area and forms the delta area ultimately balancing itself. This observation made by the committee was against the concept of holding flood water in the reservoirs. Previously attempts were made to check the floods through storage but this observation and recommendation were against to that.

The 1928 flood committee made 70 recommendations. These were only statements without any definite action plan for implementation. The report did not recommend tough action by naming particular bund , dam or reservoir. Contradictory statement was made in the report by recommending status quo of bunds , reservoirs. While the farmers who had irrigated area under the bunds pressed their importance in controlling floods , others whose lands were submerged during floods argued against them pinpointing to the devastation occurred. Between these two factions , the land owners of the irrigated area were very powerful . Thus it was not possible to remove any bund which converted the flood into devastation effect.

Raja Bahaddur of Kaniha had constructed 5.7 M high earthen bund near Gajaria to insulate his lands from floods. As recognized by the flood committee this bund was an obstacle for free flow of Burha , Kharsua , Virup and Brahmini rivers. During floods this bund submerged many villages. 1928 report recommended dismantling of this bund. The flood committee report was placed before the working committee of Orissa governor. Working committee transferred this to Public works department. But Raja Bahaddur of Kaniha was head of the public works department. Even after devasting floods of 1935, contrary to the anger , anguish and protest of hundreds of villages , thousands of farmers, multiple reports of British engineers , Raja Bahaddur was not only successful in retaining Gajaria bund but he also raised it . Other land lord , Braja Sundara Dev had constructed his own bund called Aul circuit. Both these land lords blamed each other arguing the bund constructed by the other was the reason for floods. Ultimately both

these land lords were successful in safe guarding their bunds. As the result of the tussle between these two powerful land lords , hundreds of other private bunds remained safe. Thus there was no natural free paths for rivers including Mahanadi. On Nuna river there were four such private bunds result of which the vents of Bengal-Nagapur railway bridge washed away in 1936 floods. Thousands of people protested and demanded to remove these bunds. But political moves kept them intact.

Hundreds of Such private bunds which brought revenue to British were also proud pocessions of the land lords. The main recommendation of 1928 report was to remove all such bunds. Raja Bahaddur of Kaniha and Jadumani Mangaraj urged the flood committee in 1928 , to take up construction of large dam to store flood water through which water for irrigation could be assured during summer.

Flood committee did not consider these arguments on the following reasons :

(1) There is no suitable place in Orissa to construct such a large dam. Suitable locations are outside Orissa.

(2) Orissa does not have the financial capacity to take up such large project.

(3) From engineering considerations it is possible to construct a large reservoir through high dam. But if the floods which bring large silt are stopped , in a few years reservoir will be filled with silt , losing its capacity.

After 9 years of flood committee submitting its report , in 1937 great flood brought miseries unheard before. Then the Chief minister of Orissa Bisvanatha Das requested M.K Gandhi to do something for this. After travelling two days in the flood affected area M.K Gandhi was moved by the plight of people. M.K Gandhi who visited Kannambadi a few years before had appreciation for M.V. Immediately M.V came to the mind of M.K Gandhi. M.V

without visiting flood affected areas submitted Preliminary Notes on 15/11/1937. This was based on the report submitted in 1928. M.V in his report said that he had referred other two documents but did not mention which they are. Newspaper reports and Calcutta gazette of 1931 seems to be other two references.

In beginning of his notes M.V recommended the establishment of special engineering department to take up detailed survey , engineering studies etc., It was also noted that by constructing large dam the flood water could be stored temporarily and let out in controlled manner to mitigate the devasting effects. The flood committee of 1928 has rejected this option on grounds of non-availability of such site and financial restrictions. But recommendation of M.V was to search alternate ways for such project site outside Orissa through collection of more data. In opinion of M.V , the state boundary and Cost were the major obstacles for large dam construction across Mahanadi. But M.V neglected observation made by 1928 committee regarding silting of the reservoir. It was probable that M.V who was very fond of large dams neglected it purposely. 1928 committee had the full knowledge of the huge quantity of silt brought by Mahanadi to delta area. Contrast to this M.V had Kannambadi in his mind which was at least 300 K.M above delta plain of Kaveri which received very low silt. Otherwise M.V would have suggested detail study and further investigations on silting problem of Mahanadi. All civil engineers know that construction of dam is one of the solution to mitigate floods. But for variety of reasons they do not prescribe it for all situations as an universal solution. By single statement made in preliminary report , in later days M.V was projected as the sculptor of Mahanadi -Hirakud dam project.

According to recommendation of M.V , Flood Advisory Committee (FAC) was formed. C.C Inglis (Director , Central Irrigation & Hydrodyanamic Research Station , Poona) , R.S.M Rangayya (Secretary & Chief Engineer, Public Works department , Mysore State), A. Vipin (Secretary & Chief Engineer, Orissa Govt.) were the members of the committee. In April , 1938 M.V made first visit to

delta areas of Orissa. It was an irony that to find solution for flooding , M.V visited delta areas in April when Mahanadi ran dry. During summer-April, May- rivers of Orissa appear to be very mild , weak rivers. The visit made by M.V can be compared to 'momentous' survey of Arthur Cotton in 1858. Both Arthur Cotton & M.V had some common traits. Both of them were celebrated engineers through much sycophancy and hagiography. M.V was projected as an engineer , technical wizard who knew and could provide 'losting solutions' to all problems.

In 1939 M.V submitted second note in which additional point was added cautioning the silting of rivers in due course of time resulting in raising the river bed. M.V failed to estimate the effect of river bed silting in long term and also recommend for further study. M.V was finding solutions for flooding in his own preconceived , restricted ways. In the same report somewhere else the study of river regime and the condition of people effected was suggested. M.V recorded the paradoxical situation in Mahanadi region in second note saying ' people in unprotected area ask for protection and some people in protected area want low floods and welcome inundation'. M.V did not know the answer for this and left it to the Flood Advisory Committee.

Flood advisory committee gave three intermediate reports in January , 1939 , January 1940 & February 1942. After submission of second intermediate report in 1940, A.Vipin retired and S.K Roy came to his place. First intermediate report of 1939 observed : ' Generally speaking while they (1928, Flood Committee) considered the problem as one of the disposal of excess floods , we (Flood Advisory Committee)view it mainly as one of proper distribution and disposal of excess sand' . Therefore the main aim of FAC was to ensure the conveyance of sand up to sea. Mahanadi splits into many branches as it enters delta region. The velocity of water in delta region is very low . Hence in short time the river bed will be silted resulting in spreading flood water to large area. The FAC recommendation was to restrict branching of Mahanadi in delta plain to ensure scouring velocity to carry sand to sea through

construction of earthen bunds on either banks. In 19th century engineer Lt. Haris has adopted the same technique by constructing Naraz canal to scour the silt in the Mahanadi river. This was repeated by FAC in 1942. While 1928 committee saw all bunds as sources of flooding , FAC proposed bunds on banks. The Orissa government which had seen the devasting effect of bunds rejected this recommendation.

In 1937 , M.V wrote : Enormous rivers like Mississippi and its tributary Ohio river (in the USA) the possibility of constructing flood storage reservoirs is receiving considerations' . M.V belied that to train big rivers like Mahanadi publicity , planning and authoritarian control are necessary i.e., a sustained campaign for flood storage reservoirs to receive financial backing' are necessary. In 1943 , flooding of Damodara river devasted the normal life. Then 10 member committee was formed. In 1944 , committee recommended to establish 'Damodara Valley Authority' through which central government can invest and control the project similar to TVA (Tenessene valley Authority). It was decided to take the consultancy of American expert engineers. Expert advice of American engineer W.L Voorduin was sought. A.N Khosla and M. Narsimhaiah were appointed as engineers from Indian side. In 1948 Damodar Valley Bill was passed in the parliament with full vote.

In 1945 Central waterways, Irrigation and Navigation Commission (CWINC) was established. A.N Khosla was the first secretary. A.N Khosla , an ambitious Civil Engineer was very eager to construct a dam across Mahanadi. After visiting Orissa he moved forward to implement his dream project. To avoid additional questions and queries , to obtain speedy permissions , grants , he projected himself as continuation of M.V's tradition . He propagated that as proposed in M.V's report a large dam shall be constructed across Mahanadi to train and harness it. In the first note submitted in 1937 by M.V construction of a dam was mentioned as one of the solution to a problem. Certainly it was not Hirakud dam which was conceived by A.N Khosla. Since A.N Khosla who prepared the Hirakud dam quoted M.V , it was misunderstood that the project

was conceived and designed by M.V. In future days M.V's admirers purposely to glorify him started to propagate Hirakud project came from M.V .

Operation and control of any dam constructed to mitigate floods is very delicate and complicated. In such dams the water shall not be stored beyond prefixed limit. To control the flood effects the quantity of water to be stored is decided on scientific calculations. In any duration , If the water in the reservoir is stored more than this limit , the dam cannot receive the flood water of unexpected rains. Then the large quantity of flood water has to be let out into the river in short time. By this flood like situation will be created artificially with the dam which has been built to control floods.

Hirakud dam with 756 Sq.KM spread reservoir was constructed across Mahanadi to safeguard people and property from floods. But in future years the very purpose of the dam was jeopardized. In 1960-1980 periods the recurrence of floods on Mahanadi river were more than three times that before construction of dam. In 2008 out of 30 districts in Orissa 17 were devasted by floods and Hirakud dam was able to mitigate only 16 % flood. More than 11 % of state population was affected. More than 2900 Km long highways were damaged. There were many complex reasons behind this. To control Mahanadi floods the water in the reservoir shall be stored in stages from July month and it is enough if the reservoir attains full capacity by 1st of October. Then there will be scope to store flood water during rainy season. This system was followed in the early decades of project commissioning . After this due to lack of rains Hirakud reservoir did not fill bringing anxiety. Even though the original purpose of Hirakud dam was to control floods, in future days irrigation , power generation, water supply to industries which bought revenue became the priorities. These multipurpose requirements were intrinsic in the planning. To control flood storage in reservoir shall be controlled. To gain profits from reservoir water maximum possible quantity of water shall be stored for maximum possible duration. These are mutually exclusive requirements. Among these 'profit' gained over 'flood'.

3.10 Tungabhadra Dam Construction -Technical Committee

Which is the best material for dam construction was one of the questions encountered by engineers. Stone masonry and the concrete with large sized aggregates were the contending materials for dam by the end of the 19th century. For stone masonry surki mortar can be used. The cost and the quantity of surki required is less in stone masonry than cement in conctere. Large number of skilled labors and strict supervision are necessary for masonry construction whereas concrete does not require these and most of the work is done by using machines. Construction with concrete is faster. After comparing cost & quantity of cement , the speed of construction using concrete against payment to skilled labors and slow progress, engineers preferred concrete over masonry. Therefore Mettur dam was built in concrete.

By end of 19th century most of the engineers in Europe and USA preferred concrete over masonry. But the views of Indian engineers who had great confidence in Surki mortar and stone masonry were different. Even though cement mortar and partially concrete were used in Bhatghar , Periyar and Mettur dams, Indian engineers whole heartedly had not accepted it The lack of proper knowledge of the properties of concrete and non availability of cement in India made Indian engineers to think cement mortar and concrete as costly materials. While in USA , by using concrete for Grand Cauly dam 19000 Cu.M work was achieved in a single day . Contrast to this in Aswan dam masonry work achieved was less than 1900 Cu.M - 1/10 of Grand Cauly dam. The required stone is available in abundance along with lime and surki , with cheap labor for masonry work. Therefore stone masonry is the best material of construction was the opinion of many Indian engineers.

The center line of Tungabhadra river was the boundary between Madras presidency and Hyderabad state. Mysore state had interests in Tungabhadra river as of the catchment belonged to it. Due to agreement between Madras presidency and Hyderabad states Tungabhadra project started. As a result of this Madras

presidency and Hyderabad decided to build the part of the dam which fell in their territories. Both the states engaged their own engineers. There were some technical glitches in using concrete for dam construction. Due to various chemical reactions green concrete sets and becomes hard. During such transformations exothermic reactions take place releasing lot of heat . When large quantity of concrete is used , after losing heat dam shrinks in volume. When shrunk cracks will appear in concrete dam. To avoid such cracks special designs and construction techniques shall be adopted. Indian engineers were refraining from concrete dams since it required expertancy in design and construction. Stome masonry was dearer to them.

In masonry construction one or the other type of binder or mortar is required to bond the stones and fill up the gaps. This binding material can be obtained by lime or cement. The cement to be used shall have lower quantity of Tricalcium Sillicate. In Mettur dam cement concrete was used along with and also cement mortar was the binder . To reduce the effects of shrinkage surki or brick powder was mixed with cement. By this it was possible to reduce the shrinkage effects of cement.

For Tungabhadra dam construction Madras engineers wanted to use concrete. Hyderabad and Mysore engineers were refraining to use cement mortar. Not only this there were differences among Mysore and Hyderabad practices in producing surki mortar. While in Hyderabad lime , surki and sand were mixed to produce mortar , in Mysore state lime and surki were mixed to produce mortar. There were differences and confusions among engineers regarding (a) Madras cement mortar (Cement+sand) (2) Hyderabad lime mortar (Lime+Surki+Sand) and (3) Mysore lime mortar (lime+surki). If surki mortar is used there will be no shrinkage hence no cracks was the argument of Mysore and Hyderabad engineers. Madras engineers had their own arguments. Surkii mortar cannot take stresses beyond 0.3-0.45 MPa. Surki has to be produced by powdering brick or powdering the burnt clay lumps. This surki is mixed with lime to make lime mortar. The quality and

properties of Surki depend upon the raw materials used, the burning method , the fineness achieved in grinding. By using the surki produced from raw materials of various sources different results are obtained. Therefore one must be very careful before using Surki mortar. There are no specific methods to produce surki mortar. Cement is produced in the factory in controlled condition. Therefore it is the best material to produce mortar was the arguments of Madras engineers.

To find a solution to these varying views technical committee was formed under M.V who had experience of using surki mortar in Bombay presidency and Mysore state. Therefore M.V was inclined to use surki mortar. There were technical arguments from both sides for use of cement and surki mortar. Therefore it was agreed to decide the matter on basis of technical suitability. For this compressive tests were conducted on cube specimens of Surki mortar produced by Lime:Surki:Sand in proportion 1:1:1 and 1:2:2. On the basis of results obtained the committee headed by M.V gave the following recommendations.

(1) Cement mortar shall be used for special purposes such as buildings Sluice opening, Coping of Spillway section, Piers of spillway shutters and other similar parts where special strength is needed.

(2) Lime Mortar (Lime : Surki : Sand – 1:2:2) shall be used in the Non flow sections and above the elevation of + 1580ft

After many letter correspondences , Hyderabad and Madras engineers came to the following decisions.

(1) The Spillway section shall be constructed fully in Cement Mortar.

(2) The non-over flow sections shall be constructed with Lime Surki Mortar adopting a proportion of 1:1:1 (Lime: Surki : Sand) on both the sides and that this proportion may be suitably changed for

higher elevations. Accordingly, proportion of 1:2:2 was adopted in the Dam in Non-overflow sections above the elevation of + 1580ft

After starting of the construction of dam a few more changes were made. They were :

(1) The lower 2 or 3 courses of masonry starting from foundation be built with a richer Cement Mortar of 1: 2.75 (1 cement : 2.75 sand)

(2) All the over flow section shall be finished with 230 mm thick impervious Cement mortar of 1:2.75 proportion.

(3) The pointing in the upstream face of the Masonry shall be done with Cement mortar in 1:2. On the rear side Cement mortar of 1:4 was been used up to a level of 1558' and a mix of 1:5 aove that level.

From further tests conducted it was found that there was no significant difference in strength between the mortar with proportion (1 Lime : 1 Surki : 1 Sand) and (1 Lime : 2 Surki : 2 Sand). Therefore the dam above +1580 level was constructed with mortar (1 Lime :2 Surki:2 Sand)

The role of M.V in Tungabhadra dam was limited to heading the committee which has to recommend the type of mortar to be used in construction. The recommendations of the committee were depended on the test results obtained. After starting of the construction many modifications were made with mutual consensus of chief engineers on either side.

By 1930 cement was the preferred binding material worldwide. The dams many times bigger than Tungabhadra were built using cement. In Tungabhadra dam contraction joints were proposed at 28.44 M spacing to take care of shrinkage effects. Cement was the face of the future world where as lime surki mortar was verge of being pushed to the pages of the history book. M.V was unable to see this. M.V was technically not correct while recommending both

type of mortars without trying to understand the behavior of a dam which would be built using two different materials of great contrast (i.e., cement and lime surki mortar). Stony , who retired as chief engineer of Madras presidency wrote a letter to Govindaraja Iyengar . Engineer of Madras presidency expressing his displeasure over the issue and commented that the person deputed to resolve the issue (M.V) does not look an engineer to him. Whatever may be the opinion of Stony, M.V did not take bold step regarding the mortar crossing over his old , out dated experiences. [26]

It seems that until the end M.V had fear and did not have confidence in cement and cement concrete. The bridge for movement of vehicles and gate operating cranes in Sukkur dam was proposed on stone masonry arches. During construction stage it was confirmed that Reinforced Concrete (RCC) is superior to masonry. Therefore arches and road were constructed in RCC. Without observing the ongoing advances M.V was always arguing that stonmes are available locally m masonry construction is easy , surki can be produced here etc., The concrete was the material of the day – which M,.V failed to understand. [27]

---

[26] In Bhakar-nangal project 20 % Lime surki was added to Cement to manufacture concrete and mortar. Specific scientific procedures were developed to guarantee the quality of Surki. Before this there were no established scientifics methods to produce surki with consistent quality.

[27] The history of use of cement in India goes back to 150 years. Cement concrete was used In 1866 for construction of military office in Simla and for foundations of Calcutta hiogh court building in 1869. In 1907 four storey hostel building was constructed in concrete in Bombay. By 1910 Madras , Shivapura and Thomason Engineering Colleges (Now, IIT Roorki) standardized the test procedures for cement concrete. In 1911 when bridge across Musi river was washed away due to floods new concrete bridge was constructed by M/S Marland company. By 1915 , codes of practice for design and construction of Reinforced Cement Concrete (RCC) structures were available in Britain and same were followed in India. By 1919 John Gammon was the pioneer in use of cement concrete and wrote a book titled ‘ Reinforced Design Simplied ‘ and constructed many buildings for Bombay Public Works Department. At the same time guide lines for use of cement were

4.0 OTHER ASPECTS

A few observation made on M.V which are not technical in nature but draws our attention for other reasons are given in the following pages. Experts in these fields can throw further light in this direction.

4.1 Administration

When M.V discharged his duty promptly British engineers , administrators had sent appreciation letters to him. We do not know whether that was the part of British administration. We do not have the information regarding the appreciation received by other engineers for the prompt work done by them. Also , except some 'cooked up' stories there is no information about how M.V as Diwan of Mysore state recognized dedicated , efficient officers. From M.V's Memoirs of My Working Life we do not get information whether he has recognized and sent any appreciation letters to the government officers , employees.

There is wide belief that the engineers of that period were very efficient and their dedication and duty consciousness were beyond doubt and question. It is true that corruption during those days was not much-not as rampant as now. But the symptoms of the disease of government departments were already there under M.V as Diwan. While talking in 6th annual conference of Mysore Civil Engineers Association on 27/3/1913 , M.V observes that no paper has been presented on the dam construction . He also assumes

---

published. BS-12 (British Standard-12) published in 1925 enumerated the testing methods of cement and cement concrete. By 1925 in India 25 architects and 36 civil engineers , 76 contractors declared themselves as experts in design and construction of cement concrete structures. In 1935 , in Byculla of Bomabay 'Ready Money Building' in RCC with modern concept of footing+column+ beam frame and slab was built. By 1940 Indian civil engineers clearly knew that the future conctruction would belong to RCC.

work load and lack of time may be the reasons and further hopes that by next session this omission will be supplied. M.V was satisfied on the paper presented on sugarcane cultivation in Kannambadi canal system. (7-75). After four years on 15/3/1917 , during 10th annual conference of Mysore Civil Engineers Association , M.V told thus : 'But it is disappointing to find the majority of the engineers content with the routine work of their appointments. Work is taken up spaordically and carried out without the regard to system or method. Programmes and promises are soon forgotten of being treated as debt of honor'. He previously lambasted that ' (Executive Engineer) should be a man of more than ordinary industry and character. If he is no that and is merely a hum drummer , he will have t0 make room for one who has these essential qualifications'. (7-76)

When M.V was chief engineer the technical staff was reduced but it was restored once again when he became Diwan. On and often M.V raise the issue of higher load on the engineers due to insufficient staff. M.V cautioned engineers who does only the allotted routine office work , reluctant to learn technical advancements, not aspirational and self-motivated. This has repeated in the speeches given during conferences of Civil Engineer's Association. Therefore even under M.V there were useless , reluctant engineers in public works and irrigation departments. All the engineers in Mysore state belonged to Brahmin cast- may be with one or two exceptions at rarest of the rare cases. There were no social tensions among the government engineers as a single cast dominated the entire field. M.V argued with Maharaja that through reservation inefficient are given opportunities where merit shall only be the criterion. Therefore the comments made by M.V shall be discussed in different dimensions that how the engineers selected on merit basis otherwise merited cast engineers became inefficient.

4.2 Limitations Of Responsibility / Expertancy

In the second half of 19th century British government established many departments for administrative purposes. It was struggling hard to bring working system to these departments. Therefor all engineering projects were made to pass through fixed stages such as survey, estimation , detail project report preparation and execution. Engineers were trained to work systematically in these lines. Therefore whenever engineering committees were formed the engineers in government service or the retired engineers of the government who knew the system were preferred. They were recognized as subject experts. Many times the expertancy was more to acquaintance to government procedures rather than pure technical capacity. Hyderabad and Mysore had sought services of M.V. After 1920 , due to Swadeshi movement people started to lose confidence in British engineers and doubted their intentions. British government which was aware of this preferred M.V and Nawab Ali Nawab Jung as technical experts in Bombay Reclamation Committee and Sukkur Barrage scandal committee.

M.V did not hesitate to become the member of committees which were beyond his expertancy. M.V was member of Technical & Industrial Committee (1921), Indian Economy Enquiry Committee (1925) , Karachi Municipal Finances & Administration –Survey & Recommendations (1926) , City of Bombay Corporation Resolution On Final Report (1928) , Disturbances in Bangalore City –Enquiry Committee (1928-29) etc., In 1938, Physicist Meghanada Saha argued that the Indians who are struggling for independence shall have their own 'National Planning Commission' and forced Subhash Chandra Bose who was National President of Congress party to call a meeting in Delhi. Due to some problem Meghanad Saha was unable to reach Delhi in right time. A few hours before Meghanand Saha reached the meeting venue M.V was decorating the post of President of National Planning Commission. M.V who was in old age was eager to take up membership , executive posts of any committee without any hesitation. It is evident, that he

never felt the dyanamic , enthusiastic young engineers are more suitable to such posts than himself. Meghanada Saha very well knew scientific committees can be powerful only if they are supported by political leaders and political power. Therefore he made M.V to resign the post and brought Jawaharalal Nehru to the position.

During Orissa floods M.K Gandhi had more confidence in M.V than the British engineers of Orissa who were much knowledgeable. After independence also Indian government relied upon 'old experts'. Either to decide the location of bridge over Ganga river or to decide the type of mortar to be used in Tungabhadra dam , M.V at ripe age 90 years was not required. Such issues could have been resolved by committee of engineers of age group 40-60 who have 25-30 years of experience. In line with British system prime minister Jawaharlal Nehru made M.V chairman of Ganga bridge committee. It is not appreciating matter that M.V accepted the chairmanship of bridge committee instead of transferring the responsibility to the shoulders of young energetic engineers & suggesting Nehru to build a team of such engineers. The tradition of using 'experienced expert heads' by central and state governments of India has resulted in the various complexities in India. The 'old experts' sticking to 'grand old methods' have hindered many public projects.

The tradition of taking the 'responsibility' through various 'grand posts' in the unrelated , inexperienced fields started by M.V is still unchallenged in India. The software experts in Karnataka are now providing their grand advices to build air ports, roads, tourism , transportation , infrastructure, drinking water , reforming electoral methods , village industry , public health , Adhar card and even cultural policy also.

4.3 Foreign Tours

Foreign tours are the highlights of M.V's life. M.V travelled out of India six times out of which five times to USA. It is said that the 3rd (1919) ,4th (1926) , 5th (1935) and 6th (1946) foreign travels of M.V were aimed at knowing the technical advances of developed countries and bring it back to India. When seen closely it is clear that these were the travels taken up by a consulting engineer on behalf of capitalist to start new industries. In 1898 when M.V was assistant to chief engineer in Poona circle for the first time he went to Japan for three months. We do not know whether British allowed their employees to take long leave to tour foreign countries or it was especially given to M.V or M.V accumulated his leaves for that purpose. After returning from Japan , M.V wrote a book highlighting the policies , rules and regulations of Japan government. During those days Poona was the epicenter of anti-British activities. M.V did not publish that book . M.V felt that even though the facts and opinions in the book are true , being a government engineer there may be clash of interests between his work , the government and the delicate political situation By this it can be safely said that M.V was afraid of losing job along with disciplinary action by British. M.V was very stubborn in placing his opinions in front of M.K Gandhi , Jawaharlal Nehru who had no power to take any action on him and kind hearted Maharaja of Mysore.

After submitting resignation to the government but was still in service in 1908-09 , utilizing the accumulated leaves M.V travelled out of India. This time M.V had planned for two year long tour to Europe and USA. When he was in this tour a call came from Hyderabad and trip was curtailed. In this tour M.V visited various countries in Europe including Italy , Sweden, Denmark , Russia , England, France. To gain knowledge in soil erosion and irrigation he stayed in Italy for two months. He visited large sized sewerage system in Milan and made technical notes. From there he went to USA, Canada and studied the water supply , sewerage and

irrigation related subjects. M.V has recorded that in his busy schedule he was unable to find time to publish these.

We do not know how M.V was collecting technical details in foreign countries. Because the details of large projects either public or private are not available to tourists whose travel is purely personal. Since there was no photocopying technology all the technical details including drawings were to be copied manually which requires weeks and months' time. Was so much time available for M.V , a private tourist or was M.V carrying introduction letter from British as government employed engineer. Did British supported such tours to gain technical knowledge and to know engineering achievements of other countries ? Because when Herbert Williams from Mines & Geology department of USA was sent to India in 1898-90 to study the Irrigation projects , British extended their facilities and supported him by providing all technical data. Before second world war English was unknown language in Europe beyond England and Briton and all technical data in other countries were in their respective native languages. How did M.V communicated in Italy , Russia , Denmark , Sweden, Japan –Did he employed translators we do not know.

4.4 Economic Concepts

The speeches given by M.V after he became Diwan are monotonous. In every speech he compares India with developed countries in fields of education , industry etc., M.V neither say new things nor critically examines the European models. He prefers to take the European model as it is. In the speech made on 9/6/1916 , M.V opinions that the business interests are in the back ground of world war. He further said ' But we must not shut our eyes to the fact that the war that is going on is partly an economic war , in the words of Asquith. The ongoing rivalry of the nations of the world. When it is over , the competition in trade and industries will go on relentlessly as ever and , in this economic war of nation against nation , there will be no peace'. By declaring so M.V attempted to

follow the model of nations which were warring for trade. He does not have any alternative fresh ideas.

4.5 Time Consciousness

Many legends , miraculous anecdotes freely roam regarding the discipline and time consciousness of M.V. No society can progress without time schedule. To bring discipline to follow strictly time schedule is part of the efficient administration. In large public projects huge public money is invested. Completing the project in stipulated time is the way to do justice to the public money and expectations. There is no second thought for this. But civil engineering profession is different from other professions. Many times it is not possible to complete the work within office hours. The construction activities slip in time due to unexpected practical difficulties. Therefore it is common practice throughout the world that engineers wok over time when needed and get relief when there is no work pressure. The aim to finish the project in scheduled time is perfect. For this fixed work flow , critical schedule and planning are inevitable. But this time schedule and planning cannot be reduced to hours, minutes and seconds. From the folklore legends on M.V's time consciousness and discipline , it seems that for M.V these were more of rituals than principles. There is an anecdote that once M.V sent back a student for coming late by 5 minutes for the lunch for which he was invited. If this is true then it can be assumed that M.V had stubbornness and robustness of a machine rather than social awareness, human nature and compassion.

4.6 Language

It is interesting to know the attitude of M.V towards native language including Kannada. M.V thought English as the language of the cultivated and other Indian languages as 'native', (7-346). It is also very interesting to know the language policy adopted by M.V when he was chief engineer and Diwan. English was the

administrative language of the of British. As an employee of British M.V had no choice but to follow it. Until the end of second world war English was not the international language and had no recognition in Europe. Except England no country visited by M.V in Europe had English. M.V was mesmerized by the western life and advancement and thought that it was the route of liberation for Indians. In every stage M.V compared the Indians with Europeans and praised the technical advancement , entrepreneurship , duty consciousness and their disciplined life. But M.V nowhere talks about the love shown by Europeans towards their mother tongues and prominence given to that.

Even though being native of Mysore state M.V uses the Anglicized places names such as Chitaldroog , Nandidoorg instead of correct names in use. We do not know whether he was using Anglicized word for place names while speaking also. Circumstantial evidences show that M.V believed that native languages are good only for general communication and English is the language for higher knowledge. M.V did not have any clear policy about the administrative language as Diwan of Mysore. If had such clear policy all the administrative documents of Mysore state would have been available both in Kannada and English. Even the documents which are necessary to inform and awaken the general public such as Kaveri river water dispute never appeared in Kannada. M.V did not have any vision to bring native languages to all spheres of use. If a century before M.V or other Diwans have taken such bold decisions , then the current prevailing blind and pseudo feeling of superiority of English language over Indian languages would have been controlled.

After M.V was appointed to the office of Diwan of Mysore farewell function was arranged by Mysore Engineers Association on 30/11/1912. This function was arranged under leadership of Karpura Srinivasa Rao , Krishna Iyengar , members of the association. During this function the songs in Sanskrit, Telugu , and Tamil were sung. There is no record to show Kannada was represented. It is worth subject of research to know why Kannada

was not used as M.V being the officer of Mysore state governed by who represented Kannadigas. There are no records to show that M.V wrote anything in Kannada. It is most probable that he even did not speak in Kannada except during some short interaction with villagers.

4.7 Merit & Efficiency

M.V on and often called common people and farmers as 'ignorant masses' and compare them with the people of developed European countries. He looked down their knowledge. M.V does not recognize the historical facts such as social structure controlled through caste perpetuated by Brahmins through redundant , obsolete vedas and shastras which denied the education to common people ultimately heaping up 'ignorant masses'.

5.0 MYTHS: BIRTH AND GROWTH

While talking on the occasion of Gopala Gowda Award distribution ceremony on 14/3/2014 , former chief minister of Karnataka S.M Krishna observed that it is widely propagated that the contribution of M.V was greater and that of Maharaja Nalvadi Krishnaraja Odeyar is meager in constructing Kannambadi dam. One should not forget that Maharaja Nalvadi Krishnaraja Odeyar sold royal family gold and ornaments to provide the funds for Kannambadi construction. In Mandya district M.V statues are erected everywhere, photos of M.V adore the walls of houses but none of Maharaja is the irony of the history. By this for the first time a politician who always aims at electoral dividends through votes by adhering and propagating the popular myths has told the truth.

Before M.V arrived to Mysore state Marikanive project was completed , electric generation was started. Mysore state had already moved in progressive path of modernization. When they were at the stage of gaining full speed M.V came to Mysore state. The pros and cons of Kannambadi dam construction , financial implications , the modes and methods to mobilize resources were discussed and finalized before M.V came to Mysore. If Nikholas Bernard Dawes would not have died , the responsibility of finding the solution to the pressure mounted by John Taylor Co. would be on him as chief engineer of Mysore state. The emerging situations, the financial burdens and litigation from John Taylor co., forced Maharaja Nalvadi Krishnaraja Odeyar to take up the Kannambadi dam construction immediately. Along with these Maharaja was a 'people's king' who cared and willed to good to them. Death of chief engineer Bernard Dawes and prevailing political situations resulted in appointing M.V as chief engineer. Without considering these facts it is highly bogus to claim Kannambadi is the single handed endeavor of M.V and due to his pressure Maharaja took up the dam construction.

By keeping away all sentiments if we look at Kannambadi dam construction objectively on technical grounds , the contribution

made by M.V is not significant. Even before M.V came to Mysore state , dam bigger than Kannambadi was already constructed. The design and execution of Kannambadi dam was not great engineering wonder of that day. The statement 'World famous Kannambadi' is comparable to a frog calling a well as ocean. Many such dams were already constructed in India and world. The principles of design and construction were standardized and recorded. The engineers already had found solutions to the problems that encountered during dam construction. M.V used them. That opportunity came to M.V. Any other professional engineer at the same position would have given the same result. Nothing new came out from M.V either in design or construction of Kannambadi dam. Kannambadi was one more dam among hundreds of the day.

The credit of constructing Kannambadi should go to Nalvadi Krishnaraja Odeyar and his mother Kempa Nanjammanni (Vani Vilasa Sannidhana). It is very natural that engineers dream and prepare ambitious projects. 19th century British engineers dreamt to build the majority of the existing large dams in India. They were very enthusiastic for their execution. But the priorities of the day , financial capacity/sustainability were the obstacles for them. Same obstacles were encountered in Kannambadi project. It is historical that Maharaja and his mother sold royal property to raise funds to build the dam. In Karnataka and Kannada history Attimabbe , Jaina woman of 10th century is called as 'Dana Chintamani '(Gem among Donators). Her charity and sacrifice came in the back ground of to a particular religion and belief. But the sacrifice made by KempaNajnammani was far greater than that of Attimabbe. There may thousand engineering dreams but to realize them people like Kempa Nanjammanni and Maharaja are essential. Therefore the real credit of Kannambadi project should go to this mother and her son.

When the above facts speak , it is very curious to know how and when the credit of constructing Kannambadi was deposited to the account of M.V. Central Water Committee of India has published

“National Registry Of Large Dams’ in 2009 which contain the information of completed 4710 large dams and 390 large dams under construction. In this registry no dam has been identified with a single chief engineer. But as an exceptional case , with Kannambadi dam M.V appears as ‘Bhagyashilpi’, the greatest engineer in Karnataka. It is not easy to know the name other engineers who built the bigger dams before Kannambadi in Karnataka/India. Therefore it worth to search for the reasons how and when M.V was made ’Bhagya Shilpi’.

M.V was the chief of construction as chief engineer and Diwan of Mysore state. Therefore his name appears in various records along with Kannambadi. Because of this reason the name of the engineer who built Marikanive dam which is bigger than Kannambadi is not known to the public.Even though this made to recognize M.V with Kannambadi closely there were no statues and photos in Mandya district. Shamarao in his book ‘The Modern Mysore’ published in 1936 records that Kannambadi project was proposed in 1911 and pre construction activities were in full swing when T.Anada Rao was Diwan of Mysore. He does not mention name of M.V

The advancement made in science and technology in the first twenty five years of 20th century were covered in the book released in 1936 , titled’ Progress Of Scientific Education In India During The Twenty Five Years’ . In this book advancements made by Indians and Indian resident British (Anglo Indians) in mathematics, geology, agriculture, veterinary science, diary , animal husbandry, archeology, humanities, biology, psychology , forest research, anatomy , physiology and engineering were covered. In engineering section , especially in civil engineering articles contributions made by Indian and resident British engineers in irrigation and dam construction are recognized with technical details. Among these one article discuss the new findings and explains how these were adopted in Sukkur dam construction. The material used in Mettur dam is also discussed. The names of engineers who gave new concepts to irrigation and dam construction are given. But no mention is made of either

Kannambadi or M.V. The editors have noticed no new technical aspect in Kannambadi project. As projected now , M.V was never considered as a 'tall' engineer in technical sense anywhere either by his block irrigation system or by automatic gates or by Kannambadi dam.

Maharaja Nalvadi Krishnaraja Odeyar who was 22 years younger than M.V expired early. After this M.V lived long and was in memory of public. By this time Mysore state was merged in independent democratic India. K.V. Puttappa (Now, National Poet of Karnataka) who was against non-democratic kingship wrote eulogy on M.V as ' ರಾಜರಾಜರನು ಹೊಗಳಲಾರದೀ ಕಾವ್ಯ ನಿನ್ನನ್ನು ಹೊಗಳುತ್ತಿದೆ' (the poetry which does not praise king of kings praise you o Engineer') in his poem Yantrarshi . K.V Puttappa who had come to Mysore from dense forest area of malenadu region of Karnataka , who did not have iota of technical knowledge saw ' Techncocrat Sage' in M.V.

It is very interesting to know from when M.V started to appear as 'divine achiever'. When M.V went to Chikkanayakana Halli as Diwan of Mysore Teerthapura Nanjudaiah Shrikanthaiah (known as Tee. Nam. Shree-in Kannada) for the first time composed a poem on him which starts as 'ವಿಶ್ವೇಶ, ವಿಶ್ವ ವಂದಿತ' (Lord of the Universe, Saluted by the Universe). After this when M.V reached 60 years of age , Samsa (Swamy Venkatadri Iyer) wrote a poem titled 'ಮಂತ್ರಿವರ್ಯರಾದ ಮೋಕ್ಷಗುಂಡಂ ವಿಶ್ವೇಶ್ವರಯ್ಯನವರು' –(Honourable Minister Mokshagundam Visveshvaraya) in which he euolised M.V thus : Know that Visvesvaraya came to convert our land to heaven , he is the Vishvakarma of modern times , understand his capacity and bow down to him-learn to describe his full divine life'. D.V Gundappa, jouranalist and one of popular Kannada literati through his poem 'ಮೋಕ್ಷಗುಂಡಂ ವಿಶ್ವೇಶ್ವರಯ್ಯ ('Mokshagundam Vishveshvaraiah) declared M.V as ' one who has become the master by teaching strength , fineness , liberty. The knowledgeable , honorable Vishveshvara , the embodiment of good qualities , etaernal'. ('ಪೌರುಷ ನಯೌದಾರ್ಯಗಳಂ ಬೋಧಿಪಾ ಗುರುವಾಗಿರ್ಕೆ ಗುಣಾಕಾರಂ

ಬುಧವರಂ ವಿಶ್ವೇಶಾರ್ಯಂ ಚೆರಂ') . Masti Venkatesh Iyengar , an retired IAS officer , well known literati and popularly known as 'father of kannada small stories' declared unanimously that ' you woke up the day dreamers and shown the real path of life' ('ಹಗಲ ತೂಕಡಿಕೆಯಲಿ ಕುಳಿತಿರ್ದ ಜನತೆಯನು ಎಬ್ಬಿಸಿ ಬಾಳ್ವ ದಾರಿಯನು ತೋರಿದಿರಿ) through which all modern thinking was attributed to a single person called M.V. Jnanapeetha awardee Dattatreya Ramachandra Bendre(Da.Ra Bendre) and Other literati including popular poets such as Chennaveera Kanavi , S.G Narasimhaiah who knew nothing about science and engineering , along with Narasimha Paranjape-a civil engineer wrongly thought that like great literarary works the large engineering projects are the achievements of a single person. V.S Narayana Rao who mixed up the life and technical achievements of M.V in his hagiographical work titled 'ಮೋಕ್ಷಗುಂಡಂ ವಿಶ್ವೇಶ್ವರಯ್ಯ: ಜೀವನ - ಸಾಧನೆ (Mokashagundam Vishveshvaraiah : Life and Achievements) which was also published by National Book Trust of India in 1980 sang in ecstasy that ' who is that person praised by the world, who is that person who prepared drawings, who is the person who ground surki and built dams….' . Goruru Ramaswamy Iyengar , a well known Kannda writer in his travelogue 'Amerikadalli Gorur' (Gorur in America)- which won Kendra Sahitya Academy award-spun one more myth through a legend around M.V. When poets who knew nothing about engineering were singing , praising , euologing , fanfairying , deifying M.V, the civil engineers who were supposed to critically evaluate M.V were mute and surrendered to the clever deafness. This in due course reached the pinnacle of deification of M.V.

A decade before India got independence call for planned intervention , planned development gained prominence. This was the copy of the European model. Therefore native states and the political parties along with Congress which were spearheading the independence movement had their own dreams about planned development. To fulfill the dreams Congress party formed sub committees to prepare reports. Dam construction and irrigating

vast stretches of land through water control were the visual proofs of the planned development. As the leaders of such planned development Civil engineers gained popularity. After independence role of engineers , among them civil engineers role was considered as superior.

M.V wrote 'Memoirs of My Working Life' in 1951 at matured age of 91. In 1955 he was honored with the highest award of the nation 'Bharata Ratna'. At the same time Prime minister Jawaharlal Nehru called the dams as temples of new India. In such a time , the articles written heavily concentrating M.V stood fast in the minds of the general public and slowly pushed the achievements of other engineers to oblivion. The long life lived by M.V worked as contributory factor to this phenomenon.

After M.V awarded with Bharata Ratna , based on his biography each and every work done by M.V was glorified as the wonder of engineering. After this without referring to any external sources , solely depending on M.V's own work 'Memoirs of My Working Life' articles, books emerged praising , deifying M.V as never before. The influential writers like D.V Gundappa , Masti Venkatesh Iyengar wrote articles with full of praise and worship without iota of critical outlook. Civil engineers of the day , who belonged to a particular cast joined their voices in chorus. The deification of M.V reached the new heights during his birth centenary. Legends , myths were manufactured through anecdotes and were circulated among common public. Some ardent admirers of M.V eagerly spread myths about the ' Great Head' of M.V. In due course school teachers distributed them to innocent students. In future days situation was changed to such an extent that except praising alone nothing critical exists regarding M.V.

In 1971 'Bangarada Manushya' (Golden Man) was produced & released by the well known producer K.C.N Gowda. This movie created history in Kannada filmed entertainment. Dr. Rajakumar , very popular actor , cultural icon of Kannada screen was in the lead role as a farmer. Through great acting of Dr. Rajakumar , farmers of Karnataka recognized themselves with him and got inspired. A song

in the movie enumerated and praised the greatness of Kannada and Karnataka. A line in the song 'ಕಾವೇರಿಯನು ಹರಿಯಲು ಬಿಟ್ಟು ವಿಶ್ವೇಶ್ವರಯ್ಯ ಶ್ರಮ ಪಡದಿದ್ದರೆ , ಕನ್ನಂಬಾಡಿಯ ಕಟ್ಟದಿದ್ದರೆ' (Would there be a land , land that grows gold (crop), rich land If Visveshvaraiah has not toiled to construct Kannambadi dam allowing Kaveri to flow to sea) was mesmerizing the masses. The next line of the song was 'ದುಡಿಮೆಯ ನಂಬಿ ಬದುಕು, ಅದರಲಿ ದೇವರ ಹುಡುಕು , ಆಗ ಬಾಳಿಗೆ ಬರುವುದು ಬೆಳಕು' (Relie on the life of work and toil , search for god in it, then the light of the life appear) was the rephrased statement ' ಕಾಯಕವೇ ಕೈಲಾಸ' (Work is the abode of god) of the statement made in one of the Vachanas by 12th century sharana Ayadakki Mayayya. For centuries the statement made by Aydakki marayya was in the minds of the people. The strong mesage of Work is worship, through it see the god' was cleverly linked with Kannambadi dam and M.V . By this time plenty of legends, myths were circulating around M.V. Thus deification of M.V was completed.

6.0 APPENDIX

6.1 Engineers Day

Unlike pipointing religious, cultural , social or politically relevant days it is very difficult to recognise scientists or engineers day. The aim of science and technology is to search and understand nature and adopt it to human benefit. Such a search of nature continues through constant modification , improvements , explanation. There is no end for it. Therefore any scientific or technical advancement made by anybody is not final. Therefore it is challenging to recognising a particular day as 'Engineers Day'. Therefore it is not possible to recognise any day as Scientists or Engineers day throughout the world with consensus. Therefore many countries have their own scientists and engineers day. Raman effect was explained by C.V Raman on 28/2/1928. Therefore in India 28th Febraury is recognised as Scientist's Day. Similarly 15th September, the birth dayy of M.V is observed as 'Engineers day'.

Now, nearly 40 countries observe Engineers Day or week . Arjentina, Iran and India observe this day on the birth day of a particular engineer. There are some confusions regarding the date of birth of M.V. As per one avilable janma Kundali M.V was born on 27/8/1860. But now 15th September is observed as Engineers day. The change of date of birth might have come when M.V joined school at his village.

6.2 Kallanai

There is heap of information in internet that Karikala Chola of 2nd B.C E was the first king in the world to construct a dam across a river. The Grand Anicut (Mukkombu) which was reconstructed by Arthur Cotton in 1850's is believed as the original Kallanai built by Karikala Chola. There are two Karikala Cholas , one belonging to 2nd century C.E and other to the 10th century C.E in history of Tamilnadu. Therefore confusion prevails regarding Karikala Chola who built the Kallanai. The information regarding first Karikala Chola is obtained from original oral sources of Aham , Puram literary divisions of the Sangam literature. Uruttinga Kannanar of

Sangam age has exclusively sang about Karikala Chola in his 'Pattina Palai'. In that he does not mention Karikala Chola as the builder of Kallanai but recognises him as one who strengthened banks of Kaveri. The social , political situations of Sangam era were not conductive or resourceful to take up the construction of Kallanai across Kaveri.

Tiruttani and Velenjeri copper plate inscriptions of 932 C.E belonging to Chola king Paratanka contains the genelogy and achievements of chola kings from puranic times. In this achivements of Karikala Chola are enlisted as embarking Chola emblem on Himalayas, making Kanchi as the city of palaces and strengthening of banks of Kaveri. Even these achievements are missed in Udayendram copper plates of Paratanka.In Cholamandala Shatakam written by Atmananda Desika , it is said that Karikala Chola was born in Kali 990 and he raised the banks of Kaveri. In the manuscrupts collected by Mckenji the period of construction of Kallanai is assigned diffrenetly as Kali 990 and 3090. In other manuscripts it is said that Karikala , son of Parantaka has built the Kallanai. The copper plates of chola kings Rajakesari Varma (C.E 1048) , Rajendra Chola (C.E 1016) , Rajaraja -1 (C.E 1044) , Punyakumara (C.E 1150) , Tammasiddhi (C.E 1207) declare that their ancestor Karikala raised the banks of Kaveri. If all these evidences are considered it can be safely concluded that during the reign of Aditya-1 the construction of Kallanai started and it was continued by his son Aditya Karikala (who was also known as Karikala Chola) and was completed during the reign of Rajaraja Chola. Therefore Kallanai was constructed during 10-11 centuries of current era (C.E)

6.3 Nawab Ali Nawab Jung Bahaddur

Nawab Ali Nawab Jung born in 1877 finished his primary education from Saint George Grammer school. In 1896 he was sent to world famous 'College of Cooper Hills' engineering college. Nawab Ali stood first for his class and got meritorious scholorships. In 1889 Nawab Ali Nawab Jung returned to Hyderabad and started his professional life as Assistant Engineer in Public Works Department. In 1906 he was appointed as municipal engineer and technical inspector. In 1910 he was appointed as consulting and

superintending engineer. In 1912 he became full time superindentent engineer. In 1913 he was appointed as the secretary to public works and telephone department. In 1918 Nawab Ali became the chief engineer of Public Works Department and all engineering divisions came under him. Along with this he was the chief engineer for the construction work of palace for Hyderabad Nizam. Along with M.V , Nawab Ali was appointed as the member of the committee formed to look into the allegations made for misappropriation of funds in Sukkur Barrage construction. Post of Chief engineer for Hyderabad state was created in 1886 and Nawab Ali was the first engineer to serve it. Contribution of Nawab Ali along with M.V in finding out the solution to flooding of Hyderabad by Easi and Musi rivers by constructing Osman Sagar and Himayat Sagar was laudable. Services done by Nawab Ali as the president of the subcommittee formed under the presidentship of Jawaharalal Nehru in 1939 for comprehensive study of development of river valley projects in India was very valuable.

Construction of Wyra , Paler, Fateh Nahar and Rayanapalli dams/barrages and irrigation works , constriction of bridges across Goravagu , Manjeera rivers were designed and executed by Nawab Ali. By his efforts Hyderabad was included in the map of telephone services. Disputes regarding the sharing of Tungabhadra waters arose between Madras presidency and Hyderabad state. In 1945 Nawab Ali played a major role in finalizing the agreement between these two governments.

The projects which were executed with involvement of Nawab Ali in design , execution are listed below :

Irrigation Projects : (1) Osman Sagar project/dam (2) Himyat Sagar Project/dam (3) Pocharam Project- Alayar River 1916-1922 (4) Wyra Project/dam – Wyra river 1923-1930 (5) Maneru upstream project/dam –Maneru river (6) Dhindi project/dam-Dhindi river , 1940-1943 (7) Kadem project/dam

Proposed Irrigation Projects : (1) Devanur project , Ghanpur-Manjira river (2) Koyil Sagar Project-Peddavagu river ,1947-1954 (3)

Sarala Sagar project-Chinnavagu , 1947-1959 (4) Musi Project, Nalgonda Dist, Musi River , 1954-1963 (5) Nandikonda Project (6) Pochampad project (7) Rajoli banda diversion project (8) Pendlipakula Project (9) Purna project (10) Icchampalli –Maneru downstream project (11) Pen ganga Project

Buildings : (1) Arts College Bhavan , Osmania University (2) State Central Library , Afzalgunj, Hyderabad (3) Osmania General Hospital , Hyderabad (4) Yunani Hospital , Hyderabad (5) Hyderabad House, Delhi (6) Osmania Jubilee Hall , Public Gardens , Hyderabad (7) Mehaboibiya Balika Pathashala (8) Civil Hospital , Nanded (9) Nijamia Shahakhana , Hyderabad

Bridges : (1) Krishna Bridge-Anagunda (2) Bhima bridge-Yadagiri (3) Godavari bridge-Sona (4) Manjira bridge –Bandapalli (5) Munneru bridge-Khammam.

Even though the services and engineering achievements of Nawab Ali Nawab Jung were as varied , vivid and equal to as that of M.V , he did not receive same praise either during his life time or after death. Telangana Engineers Association aboserved this anomaly and trying to highlight his achievements. The Telangana Rastriya Samiti which came to power in 2014 declared 11th July , the birth day of Nawab Ali Nawab Jung as Telangana Engineers day.

6.4 India-Egypt-Aswan Project

British who occupied Egypt in 1882 instead of ruling themselves , appointed committee of ministers and supervised them. Controlling water by constructing dam across Nile , utilizing it to grow cotton and supply it to mills in England at cheap rates was the aim of British. They had their own plans to conquer the political space through technical capability and control of water. For this they had Indian engineers in their mind.

To execute the irrigation projects in Egypt experienced civil engineers from India were transferred to Egypt. It included

prominent engineers like Colin Scot Moncrieff , William Willcocks, Hansberry Brown , Jasmine Ross. Even though the post of Inspector General of Irrigation was reserved for Egyptians , all other important posts were occupied by British engineers.

Colin Scot Moncrieff who served as Irrigation Commissioner of India was deputed as Inspector General of Public Works Department of Egypt. In 1885 he has opinioned that in irrigation engineering the experience of the Indian British engineers is better than that of England engineers. Pressurizing the government he transferred Indian British engineers to Egypt. Colin Scot Moncrieff was the key figure in forming the irrigation policies of Egypt. Indian British engineers Sir William Willcocks, General Justice Ross , Sir William Gerstein , Major Hansberry Brown , Murdoch MacDonald who were active in conceptualizing designing and executing the irrigation projects occupied the post of Inspector General of Irrigation department of Egypt. They had one or the other relation with Indian irrigation department. They were resolving the problems faced such as identifying the suitable location for dam construction , canal alignment , water taxation , technical and financial issues through the experienced gained in India.

Constructing a dam across Nile was not as easy task as across ordinary rivers in India. Nile was bigger , mightier and hundred times in magnitude of flood when compared to Indian rivers. Therefore discussions rose among engineers regarding the location of dam. Colin Scot Moncrieff who first proposed to construct a dam across Nile has suggested that an expert technical committee of French , German , English or American engineers shall be constituted and this committee shall submit report regarding feasibility of the project , designs and costs within a period of 3-4 months.

In 1891 Sir Colin Scot Moncrieff appointed William Willcocks serving in India as General Director of Study of Nile irrigation project. Under leadership of William Willcocks a team of 5 British and & Egyptian engineers team toiled for 4 years to prepare the

detail project report. As required additional engineers were also involved in this. It took four years -1891 to 1894-to prepare the complete project report of the Nile project. This report had four alternatives, their technical details , estimates , BOQ along with 37 engineering drawings. Among these alternatives Aswan site was found most suitable. To determine the suitability of site for dam foundation expert advice of two geologists Professor Sikenberger and Hudson Biyere was obtained.

In dams constructed in India flood water was passed over waste weir constructed over the body of the dam. Floods of Nile and the sediment it brought were far greater than the Indian rivers. Therefore if regular dam with top waste weir was to be built across Nile then in a few years it would silt up reducing the capacity of the reservoir. If flood water is passed through the dam with higher velocity then sediment would be carried away to the downstream. This is not possible with waste weir on the top of the dam. Therefore it was necessary to provide vents in the body of the dam. When flood water passes through these vents it would carry the silt to downstream plain enhancing the fertility. Therefore large vents were provided in the body of the dam.

For British engineers and government Nile project was a feasible project awaiting execution. But they had their own fears regarding the success of such large project. Since the project report prepared by William Willcocks involved the construction of largest dam in size and capacity in the world , to evaluate its pros and cons 5 technical questions were framed in 1894 and they were submitted to the 3 member committee of expert engineers. Sir Benjamin Baker (Vice President- Institute of Civil Engineers, London , Britain) , Auguste Boule (Inspector General Pontes De Shauses, Paris , France) , Giacomo Toricelly (Professor of Irrigation and Agriculture , Naples, Italy) were the technical experts of the committee. During this time French was the administrative language of Egypt. Among 3 expert engineers Auguste Boule and Giaccomo Toricelli did not know English. Except english Benjamin baker knew no other language.

On 26/2/1894 committee held its first technical meeting and visited all sites recognized in the detail report and submitted its report on 10/4/1894. Within 40 days committee studied the entire report comprehensively. Benjamin Baker and Giacomo Torizelli approved the project by accepting the location of dam proposed by irrigation department of Egypt but identified the defects in design and suggested more than ten major changes in design. But other member August Boule did not agreed to the decision of other two members and submitted his own separate report. In it he had recognized the different design problems , suggested to carry out further study , revise designs and place it before the committee of expert engineers from Europe.

Benjamin Baker and Giacomo Toricelli had questioned the dam design principles outlined by William Willcocks in the project report. All the formulae available on date for design of dams (Sazilly , Dolecre , Rankin) and methods (Bouvier, Molesworth, Unwin) considered the solid dam with no significant openings in the body. But these formulae and method were unsuitable for Aswan dam which had large openings in the dam body. Such dams shall be designed considering the stress concentration and distribution around large openings which demands research , academical effort and time which a practicing professional engineer cannot have and adopt immediately. Therefore Benjamin Baker and Toricelly had recommended to reduce the size of the openings to the minimum possible and thicken the wall around openings. They also suggested the foundation on straight line rather than on curved alignment. Ultimately the design of Aswan dam was based on the prevailing principles , formulae and methods of the day but with some modifications done to account for large openings in the dam body. Technical committee had shown the defects in design. The engineering department of Egypt which feared that if these were accepted as the defects then their technical competence would be in question , hence it called them as ‘recommendations’. August Boule the third member argued that since the modifications suggested by other two members has

deviated too much from the original designs made by irrigation department , redesigning of the dam was inevitable.

William Willcocks , the original designer of the dam did not accept the modifications suggested by the technical committee and declared that since these modifications were far away from his original designs, his name should not be attached with the designs. There were rumors that French government was obstructing the British projects through the French technical committee member August Boule. The British foreign affairs ministry had informed the Italian government to caution Giocomo Torizelly not to align with French August Boule. Since Giocomo Torizelli approved the project prepared by the British engineers , the masonry work of the Aswan dam was awarded to Italian masons.

The challenge to provide huge money required for the project stood in the way. An investment of 14 lakh pounds for dam construction and 20 lakh pounds for other works was estimated. British government was in no mood to invest such a large sum. Many alternatives were worked out. Ultimately financial support from banks and repayment of in 30 years period including interest was worked out. Benjamin Baker and builder John Eyred were living on same street of London and known each other. Benjamin Baker succeeded in engaging John Eyred to construct the dam with repayment in 30 years.

Many Egyptian engineers were part of Aswan dam design and project. But British engineers who had superiority complex about their race thought that because of their leadership that was possible and names of Egyptian engineers were pushed to oblivion.

By 1907 demand for water increased and it was not possible to fulfill the it. Therefore it was decided consensually to raise the five year old dam. Benjamin Baker took up this problem. He proposed to increase the thickness of the dam by widening the foundation . The old and new part of the dam were structurally integrated by providing steel stitch bars. After completion of the dam , in 1902 Benjamin Baker had observed the cracks in dam formed due to

shrinkage of masonry. He also explained that when old and new dam are stitched together these cracks would disappear. Benjamin baker conducted studies on rubber models of the dam to know the stress distribution.

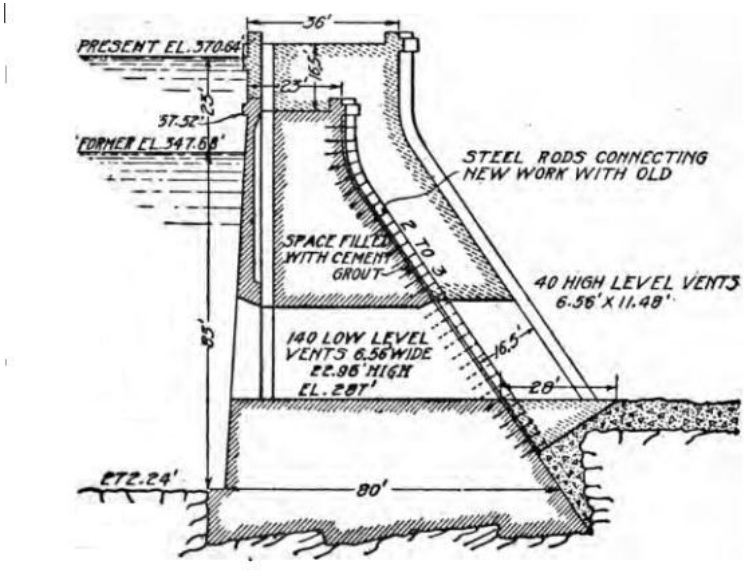


Fig. 30. Assuan Dam across the Nile Showing Old and New Profiles

ASWAN DAM: OLD AND NEW PROFILES

6.5 Failure Of Panshet & Khadakawasla Dams

Panshet dam, a rolled earthfill dam was constructed across Mutha River 22 KM upstream of Khadakawasla dam and 35 KM upstream of Poona city in the years 1957-61. The rivers Mula and Mutha join together just outside the city of Pune. The river is called Mula-Mutha after the confluence as it passes through the middle of the city.

The monsoon rain which was started on 25/6/1961 turned into heavy pours and the next day 320 mm rainfall was recorded. Heavy rainfall continued intermittently upto the end of same month.

From 1/7/1961 rains started to lash heavily reaching a maximum on 9/7/1961 recording 210 mm. Next day- 10/7/1961- the down pour reached its peak recording 420 mm rainfall. Heavy floods were reported in Panshet reservoir resulting in breaching of the dam on 12/7/1961. The large quantity of water stored in Panshet reservoir released due to breach in the dam along with flood water reached Khadakawasla reservoir which was 19 KM downstream and 13 KM upstream of Poona city. 7 hours after breaching of Panshet dam , the Khadakawasla dam also breached. Both the dams failed in the day time damaging 4420 houses in city and 630 houses in villages affecting nearly one lakh people.

A number of technical explanations were put forward for the causes of failures of both these dams. These explanations were either controversial or complementary. After inspecting the remainings of these dams experts differed in views and putting forth the reasons. The Government of Maharashtra, decided to order an inquiry and appointed a one-man Commission of Inquiry (1961) to inquire into the failure and report on: (a) The causes of the failure of the two dams and the circumstances in which the failure occurred; and (b) The adequacy of the action taken before, during and after the disaster to mitigate the consequences thereof. When Khadakawasla dam failed famous 'Automatic gates' of M.V were also washed away. We do not know in future whether they were recovered or not.

6.6 Tippu Sultan & Kannambadi

During the construction work of Kannambadi Dam a tablet with a Persian inscription of Tipu Sultan dated 1794 C.E was found by workers. Nalvadi Krishnaraja Wodeyar , the Maharaja of Mysore had the inscription installed along with its Kannada and English translations at the entrance of the KRS Dam when it was inaugurated in 1932. The contents of the inscription are available on internet for those who have the curiousity. But at present the technical issues regarding the nature and capacity of the dam are discussed.

What type of dam did Tippu wanted to build ? It is very difficult to answer. There was already 600 (400 ?) years old dam of average height of 4 M (Madhava Mantri Katte) across Kaveri river down stream of Kannambadi near historical place Talakadu. Madhava Matri Katte irrigates 5600 Hectares (14000 Acres) of land. If Tippu had in mind to build similar dam it was not much of significance.

Mir Alam tank was built across Musi river near Hyderabad in 1806. The dam consists of series of vertical semi circular arches of various spans. 21 arches whose Spans vary from 25.315 M (80') to 42.09 M (138') with maximum height of 10 .00 M (33') cover total length of 915 M (3000') on curved plan. There is no direct information on the designer of this dam . But as per some sources (Imperial Gazetteer of India (1908), vol.XIII, 311) French designed and built this dam at cost of 8 lakh Rupees. Michel Joachim Marie Raymond (1755–1798) belonging to French military was active in Hyderabad from 1786 and assembled a military force recruitimg some French personnel. He was coordial with Tipu and this led the British to eradicate French influence in Hyderabad pushing the name of the French engineer who built the dam to oblivion. It is also possible that the work started by French was completed by British.

If suppose Tippu Sultan had taken the help of French to build the dam based on contemporary engineering knowledge then very interesting facts emerge. The storage capcity of the dam at storage height of 18.3 M (60') and 24.4 M (80') is 0.0062 BCM (0.217 TMC) and 0.18 BCM (6.383 TMC). It is very interesting to compare this with Tonnur tank built in 11th century across Lokapavani river , tributary of Kaveri. Tonnur earthen dam is 24.4 M (80') in height with total sorage capacity of 0.022 BCM (0.78 TMC). The approximate quantity of masonry stone required for Kannambadi dam for 18.3 M (80') and 24.4 M (80') level are 1,50,000 Cu.M & 3,00,000 Cu.M. Consodering cost of construction of dam at Rs. 15 /Cu.M (50 % 0f the rate incurred for Kannambadi dam completed in 1932) , the amount required for 18.3M (60') & 24.4 M (80') would have been Rs. 22.5 Lakhs & 45 Lakhs. Therefore , Tippu Sultan who was always engaged in war with British and others did

not have the required resources to construct dam even of 18.3 M height (60').

6.7 Fabricating Myths and Perpetuating Legends : A Case Study

Goruru Ramaswamy Iyengar is (was) one of the popular writers in Kannada. He is well known for humorous and romantic picturisation of village life of Karnataka, especially Hasan region. He visited USA , along with his wife during 1977-78. After this he had penned a travelogue titled 'Amerikadalli Goruru (Goruru in America) in Kannada which was honoured with Kendra Sahity Academy Award in 1980. Goruru Ramaswamy explained an anecdote regarding M.V when he visited 'Hungry Horse' dam in USA. This anecdote goes like this : A security officer at Hungry Horse dam who was aged about 75 years queried Goruru whether chief engineer M.Visvesvaraya is still alive ? Gorur replied that only recently he had passed away at the age of 102 years. Hearing this security officer exclaimed "Oh" and said he was grand old man , a giant among engineers. When he came here , all the chief engineers of America assembled to hear him. He examined the construction closely for more than an hour and gave verey valuable suggestions.

From facts and records it can be shown that Goruru Ramaswamy Iyengar who knew nothing about civil engineering and who spun attractive village stories also 'manufactured' a myth to glorify M.V.

In USA , Electrical power was one resource necessary for all wartime manufacturers. Increasing need for emergency water storage for wartime electricity influenced serious consideration for the Hungry Horse multi-purpose dam, with hydro-electric power as one of its main functions. USA congress accorded permission for multipurpose Hungry Horse dam project on 5/6/1944 on the condition that work should proceed when war conditions permitted the diversion of resources to the project. It was planned to regulate the release of water to Grand Coulee and Bonneville Dams on the Columbia River to increase their power production

through Hungry Horse dam along with its own hydro-electric power generation and protection of agricultural lands in the Flathead Lake area against floods.

The milestones of Hungry Horse project are : (a) Appointment of Paul A. Jones as Project Engineer, January 16, 1945. (b) Commencement of Pre-construction work in August 1945 (c) Beginning of construction of power plant 10/7/1948 (d) commencement of exacavation of diversion tunnel 3/11/1947 and completion on 11/11/1949 (e) Clearing of reservoir site May , 1947 to 24/9/1951 (f) First concrete of main dam poured on 7/9/1949 and final pour on 4/10/1952 (g) Commissioning of Power plant by president Harry S Truman on 1/10/1952.

In his 6th foreign trip M.V visited USA in 1946. In 'Memoiers of My Working Life ' M.V recorded thus : " From England we proceeded to the United States of America and Canada, where too we visited many important industries including the Niagara Falls Hydro-electric Power Station and several large engineering works in Chicago. We spent some days visiting the automobile factories both in Detroit and Windsor across the Channel. We also visited an aircraft factory near New York. As I was personally interested in the TVA (Tennessee Valley Authority) I paid a visit by myself to Knocksville (Knoxville) from New York and returned by air. After completing the tour in the United States of America and Canada some of us visited, in separate batches, industrial establishments in France and other parts of Europe. Before the delegation left England for the last time, we visited the British Trade Fair in London in December 1946."

The historical land mark project of USA , Tennessee Valley Authority (TVA) was created by congressional charter on 18/5/1933 to provide navigation, flood control, electricity generation , fertilizer manufacturing, and economic development to the Tennessee Valley, a region particularly affected by the Great Depression. TVA's service area covers most of Tennessee, portions of Alabama, Mississippi, Kentucky , and small slices

of Georgia, North Carolina and Virginia. Knoxville the administrative centre of TVA is 1275 KM from New York. Hungary Horse dam is in Montana state which is 3390 KM away on road route. It is very clear from M.V records that he went to Knoxville to know the technical advancements and planning as a knowledge seeker and not as an subject expert.

Hungry Horse Dam is an arch dam. The 'expertancy' of M.V in dam designs is very dubious. He was neither an expert in arch dam designs nor a execution expert who would suggest advanced methods in construction.

In 1943 , devastating flood in Damodar river in Bengal culminated in formation of 10 member Flood Enquiry Committee. Scientist Meghanada Saha was one of the members of the committee. In a note circulated in March 1944, Meghnad Saha declared : " Of all the river basins in the world, the Damodar Valley presents the closest parallel to the Tennessee Valley, though on a smaller scale. The radical solution of the problem of the Damodar Valley lies, therefore, in the adoption of similar procedure as has been done by the U.S. govemment through the TVA, with necessary modifications".

The Enquiry Committee which was influenced by Saha's views decided to tackle floods in the Damodar basin on the model of the TVA. The recommendation of the flood committee received in August 1944 were forwarded to the government of India. In one of the subsequent communication to the Viceroy, R.G. Casey the Governor of Bengal argued that the nature of the works required "a really high level man or men from say, the United States" and added "that there is no one in India who could advise us on the highest level".

Through the contacts of the office of Lord Halifax , British Ambassador to America, the services of W.L. Voorduin, a senior engineer on the staff of the TVA was arranged. Voorduin was appointed as member of the Central Technical and Power Board (CT&PB). He prepared a Preliminary Memorandum which outlined

a plan for flood control, irrigation, power production and navigation in the Damodar Valley. Voorduin's proposals were scrutinised by an "expert body" comprising two engineers from the TVA, who were part of a U.S. Technical Mission in 1946 along with two Indian engineers A.N.Khosla and M. Narasimhaiya. The expert body approved Voorduin's proposals without delay. The debt to the TVA was also acknowledged in the debate in Parliament in 1948. Thus , even in India M.V was not considered as an 'expert engineer' for all civil engineering problems.

Goruru Ramaswamy Iyengar, who had heard and read hagiographical accounts on M.V wanted to contribute his own myths and legends as part of his literary ventures. Goruru with his fertile imagination created a role of 75 year old security guard at Hungry Horse dam enquiring about 'genius engineer M.V'. He also dreamt M.V surrounded by 'all American chief engineers' eager to receive his 'expert adbvices' on dam design and construction. V.S Narayan Rao liked this story and included in his book on M.V . It is very shameful on part of National Book Trust of India which published such hagiographical accounts written by V.S Narayan Rao. It is also very interesting to note that the people like Goruru Ramaswamy Iyengar are now also very active in fabricating myths and legends around Infosys N.R Narayanamurthy and his wife Sudha Murthy.

BIBLIOGRAPHY

(1) Memoirs Of My Working Life – Sir M.Visvesvaraya , Ptd.; F. Burton For G. Claridge & Co., Ltd., Coxton Works , Frese Road , Fort , Bombay – Published : M. Visvesvaraya , Uplands , High Ground , Bangalore – 1951

(2) Irrigation in India (Second Edition)- Herbert M . Wilson, Department of the Interior Under United States Geological Survey , Water Supply and Irrigation , Paper No. 57 , Charles D. Walcott , Director ,Washington Govt Printing Office- 1903

(3)The Design and Construction of Dams Including Masonry , Earth, Rock-Fill and Timber Structures and The Principal Types of Movable Dams (4th Edition) Edward Weggman, John Wiley and Sons , New York- 1899.

(4) The Forgotten Chapters in Dam History- Masonry Dams in British India in 19th Century , -Mike Chrimes, Proceedings of the The International Congress an Construction History Calcutta , May 2009

(5) British Irrigarion works in India's Krishna Basin -Bret Wallach , Journal of Historical Geograaphy 11.2 (1985) 155 -174 Revised 2004

(6) Sir M.Visvesvaraya : A Study- Y.G. Krishnamurthy 2nd Impression , The Popular Book Depot , Lamington Road , Bombay 1950

(7) Speeches By Sir M.Visvesvaraya -,Diwan of Mysore 1910-11 to 1916-17 , Govt. Press –Bangalore ,1917

(8) Masonry Dams From Inception to Completion –C.F.Courtney , D.Von Nostrand Co., New York , Crosby Lock Wood And Son ,London , 1897

(9) Studies on the Contruction of Dams : Earthern and Masonry- E.R Matthews Charles , Girffin and Co Ltd., London, 1919

(10) Engineering For Masonry Dams – William Pitcher Creager , John Wiley & Sons Inc-1917

(11) Irrigation in British India –Losing Asia , Modernisation & The Culture Of Dvelepoment -Bret Wallach , John Hopkins University Press-1996

(12) The Gazette of India , January 18, 1902 , Part 11, Govt of India , Department of Revenue and Agriculture , Inventarion and Design 16/01/1902

(13) Irrigation Works Of India (Second Edition) – Robert Burton Buckley , E & F.N Spon Ltd., 57 , Hay Market , London-1905

(14) The Grand Anicut Across Kaveri , Thiruchirapally – Past & Present Modernisation –Revisted : A. Ranjith , Indian Streams Research Journal , Volume 3 , Issue 5 , June 2013

(15) Trichinopoly Gazettier

(16) Hydrology & Water Resources of India – Pushpendra K. Agarwal , Vijay P. Singh

(17) Early Irrigation Under the British 1843-1932 – M.H. Panhwar, Reproduced by Sani Hussain Panhwar

(18) Irrigation Canals and Other Irrigation Works Including The Flow of Water in Irrigation Canals & Open & Closed Channels Generally With Tables , Simplifying & Facilitating the Application of Kutter , D'Arcy & Bazin - P.J. Flynn , SanFrasisco , California -1892

(19) Big is ugly ? How Large Scale Institutions Prevent Famines in Western India - Donald W. Attwood.

(20) Aqueduct Commission – Two Reports on the Research Concerning the Design and Construction of High Masonry Dams in View of the Proposed Building of Quaker Bridge Dam – B.S. Church & A.Fteley-1887

(21) Masonary Dam Design Including High Masonry Dams -Charles.E. Morrison and Orrin L. Brodie (Second Edition, Revised and Enlarged) John Wiley and Sons Inc, Ne York , Chapman Hall Ltd; London 1916

(22) Nalvadi Krishnaraya Wodeyar – B. Shiek Ali, Knowledge Society Publications , Mysore 2014.

(23) Advance Mysore : The cultured Logic of a Developmental State -Chandan Gowda 17/7/2010 Vol XLV No 29 , Economic and Political Weekly.

(24) Water Power Engg. – M.M.Dandekar

(25) Institutions Technology and Water Control : Water Users Association and Irrigation Management Reform in Two Large Scale Systems in India –Vishal Narain, Wageningen University, 28 April 2003.

(26) Benchmark Studies On Modernization Of Irrigation System : Operational Management By Way of Canal Automation In India , Anil B. Mandavia

(27) History Of Hydraulics In India – Prof. B.S Thandaveshvara , Indian Institute of Technology , Madras

(28) A History Of Agriculture In India - Volume III , 1757-1947 - M.S. Randhava ,D.Sc., I.C.S. (Retd.,) , Fellow, Indian National Science Academy , Iindian Council Of Agricultural Research , New Delhi – 1983

(29) Inter - State Dispute over Water and Safety in India: The Mullaperiyar Dam, A Historical Perspective - A.J. Thatheyus , , Delphin Prema Dhanaseeli , , P.Vanitha , American Journal of Water Resources, 2013, Vol. 1, No. 2, 10-19

(30) The Kaveri & The Maukharis And The Sangam Age - T. G. Aravamuthan , The University Of Madras , 1925

(31) History of Tipu Sultan -Mohibbul Hasan

(32) Splendour of Royal Mysore - The Untold Story of Wodeyers –Vikram Sampath

(33) Concrete Dams –Theory and Practice of Contstrution –Jackson Heath Wilkinson , 1916

(34) Interaction Effect of Gravity Dam with Earth Backing – Anand S. Arya , Shashi K.Thakkar , Scool of Research & Training in Earthquake Engineering , University of Roorkey.

(35) Strengthening of Masonry Dams By Earth Fill – A.R.Chandrasekharan , N.C.Singhal , K.K.M Menon , Department of Earthquake Engineering , University of Roorkey.

(36) Dam Maintainance & Rehabilitation (p-730) ,Edited Z.A. Lionas & Others , Swets & Zeitlinger , Netherlands , 2003

(37) Dams : Inscidents & Accidents - Dr. K.R Saxena , V.M Sharma 38. Harnessing the Nile –Frederick Courtland Penfield , Mid wInter Number , Vol. LVII , No.4 , Febraury 1899 , Century Magazine.

(38) Legacy of the Nizams – Dr. Lallan Ray

(39) Design of Dams – K.L. Rao , Vol XVI-No.6 (November-December) , Procedings of National Institute of Science , 1950

40) Water Resources Engineering – Principles & Practices (Revised Second Edition) Satyanarayana Murthy Challa , New Age International Publishers -2006

(41) Engineering the Nile : Irrigation And The British Empire in Egypt , 1882-1914 – Claire Jeen Cookson Hiils , Queens University Kingston , Ongtorio , Canada-2013

(42) Perennial Irrigation & Flood Protection For Egypt- Reports of the Technical Commission On Reservoirs With A Note By W.E.Garstin , Under Secretary of State , Public Works Department (Translated from French) Cairo , National Printing Office-1894

(43) Harnessing the Nile – Frederick Courtland Penfield , Century Magazine , Vol. 57, Issue -4 , Febraury-1899

(44) Construction Of Masonry Dams – Chester W. Smith , Consulting Engineer , MacGraw –Hill Book Co., Inc., 239, West , 39th Street , NewYork , 6, Bouverie Street London E.C-1915

(45) Dams & Weirs – An Analytical & Practical Treatise on Gravity Dams & Weirs ; Arch & Buttress Dams; Submerged Weirs & Barrages-W.G.Bligh , American Technological Society –Chicago , 1915

(46) Irrigation manual- H.C.K Bhatta , Bangalore Press , Mysore Road-1959

(47) Inside-Outside : Twi Views of Social Change in Rural India- B.S. Baviskar , D.W. Attwood , Sage Publications , India , 2014

(48) Report on Perennial Irrigation & Flood Protection For Egypt- W.Willcocks & W.E Garstin Cairo , National Printing Office-1894

(49) High Masonry Dams – John B. McMaster , D.Von Nostrand Publication , 23 Murray & 27 Warren Street , NewYork -1876

(50) The Dams That Failed- Ambursen Hydraulic Construction Company , Federal Street , Boston , New York , 1932

(51) Indian Storage Reservoirs With Earthen Dams- William Lumisden Strange , E & F.N Spon Ltd., 125 Strand , New York -1904

(52) Tables For Earthen & Masonry Dams – R.C. Anderson , Henry & King Co., London – 1876

(53) Practical Designing of Retaining Walls With Appendecies On Stresses In Masonry Dams- William Cain , (7th Edition) D.Von Nostrand Co., 25 , Park Place , New York , 1914

(54) A Text Book Of Retaining Walls & Masonry Dams – Mansfield Merriman , John Wiley & Sons , 53, East Tenth Street , 1892

(55) Enquiry on Dam Failures , Toranto , 1910

(56) Design & Construction Of HydroElectric Plants Including A Special Treatment Of The Design Of Dams- R.C. Breadsley , McGraw Publishing Co., 1907

(57) Reservoirs For Irrigation , Water -Power & Domestic Water Supply- James Dix Schuyler , John Wiley & Sons , New York , 1909

(58) An Experimental Study Of The Stresses In Masonry Dams- Karl Pearson , A.F. Campbell Pollard . Wheel & Richmondson , Draper's Company Research Memoirs , Technical Series, 1907

(59) Engineering Modernity : The Aswan Low Dam & Modernising The Nile – Travis Cook , department Of History, Capstone Papers , western Oregon University -2013

(60) Irrigation – Sir Hanbury Brown (3rd EditionRevised) Constable & Co., Ltd., 10, Orange Street, Leicester Square , WC-1920

(61) Irrigation Works – R.O. Reynolds , Published By Superindentent , Govt Press Madras, 1906

(62) Manual Of Irrigation Engineering (2nd Edition) – Herbert M. Wilson , John Wiley & Sons , NewYork , Chapmann & Hall Ltd., London , 1898

(63) River Training & irrigation , Chairman: Nawab Ali Nawaz Jung Bahaddur , National Planning Committee Series , (Report of Sub Committee) Vora & Co., Public Ltd., 3, Round Building , Kalabadevi Road , Bombay-19

(64) On The Water Front – Water Distribution Technology & Agrarian Change In A South Indian Canal Irrigation System-Peter Paul Mollinga , Ponsen EnLooigen, Wagenisgen, Nethelands, 1998

(65) Supplement To The London Gazette , 3 Jun 1915

(66) The Life of Collin Scot Moncrieff – Edited by Mary Albright Hollings , John Murray , Albemarle Street W. , 1917

(67) The Modern Mysore – M.Shyama Rao , Higgin Bothams, 1936

(68) The Failure of Bouzey Dam in 1895 – Norman A.F Smith , Vol. 10 , Construction History ,1994

(69) Study On Resrvoir Walls – J.B. Krantz , Translated From French By F.A. Mahan , John Wiley & Sons , 15, Astor Place, 1883

(70) Analysis Of The Historical Profiles Of Sazilly , Delocre & Rankine – E.M Bretas , J.V Lemos , P.B.Lourenco , Portugal

(71) The Edinburgh Gazette , Page – 1080, October 18 , 1910

(72) Moral Instruction : Its Theory & Practice, F.J Gould , Longmans, Green & Co., 39 Paternoster Row , London -1913

(73) Modern Indian Business History: A Bibliographic Survey - N. Benjamin and Prabhash Narayana Rath , Gokhale Institute of Politics and Economics , Poona 411004.

(74) The Design & Construction Of Storage Reservoirs –Arthur Jacob , D.Van Norstrand , Publisher , 23 Murray & 27 Warren Street , 1873

(75) The Sukkur Barrage Irrigation Project 1920 –F.W. Woods , December 24, 1926, The Engineer

(76) The History of Large Federal Dams: Planning, Design, and Construction - David P. Billington, Donald C. Jackson, Martin V. Melosi , US Department Of The Interior Beareau Of Reclamation

(77) Comparison of Design and Analysis of Concrete Gravity Dam - Md. Hazrat Ali , Md. Rabiul Alam, Md. Naimul Haque, Muhammad Jahangir Alam , Natural Resources , 2012, 3, 18-28

(78) Indian Water Power Plants –Shiv Narayana , Pub: Brij Narayan Esq. Poona, 1937

(79) Iron & Charcoal – The Industrial Fuel Wood I Minas Gerias – Frank Akerman & Paulo Eduardo Fernades de Almeda

(80) National Registry Of Large Dams – 2009, Central Water Commission , New Delhi

(81) తెలంగాణ సాగునీటి రంగ పితామహుడు నవాబ్ ఆలి నవాబ్ జంగ్ బహద్దూర్ – శ్రీధర రావు దేశపాండె , తెలంగాణ్ ఇంజినియర్స్ జె.ఎ.సి , తెలంగాణ రిటైర్డ్ ఇంజినియర్స్ ఫోరం , హైదరాబాద్ , ౨౦౧౩

(82) Water Management Across Space And Time In India – Farhat Naz , Saravanan V. Subramanian , Working Paper Series-61 , Centre For Development Research , Department Of Political And Cultural Change , University Of Bonn ,2010

(83) Nile Dams & Reservoir – Sir Benjamin Bakaer , Popular Science Monthly /Vol. 62 /April 1903

(84) The Life Of Collin Scot Moncrief – Edited by Mary Albright Hollings , John Murray , Albemarle Street , London , 1917

(85) Practical Design Of Irrigation Works- W.G. Bligh , Archibald Constable & Co., Ltd., 10 Orange Street , Leicester Sq. W.C. , London , 1907

(86) Speeches By His Highness Sri Krishnaraja Wadiyar Bahaddur Maharaja Of Mysore 1902 -1920 , Ptd. Got. Press , 1921

(87) Spillways For Reservoirs & canals – A.T Mitchelson , Bulletin No. 831 , 25 Aug 1920 , United States Department Of Agriculture , 1920

(88) Operation, Monitoring & Decommissioning Of Large Dams In India -Dr V.P. Jauhari , Environment, Forests, Science & Technology , Department; Andhra Pradesh State; India , Draft working paper of the World Commission on Dams ,1999

(89) Building The Empire, Building the Nation: Water, Land, And The Politics Of River Development In Sind, 1898 - Timothy Daniel Haines , Royal Holloway College, University of London.

(90) Tamil Nadu PWD – Past & The Present , TNPWD Platinum Jubilee Publication , Association Of Engineers & Asst. Engineers Association , 2011

(91) Annual Report 2009-10 , Tungabhadra Board , T.B Dam Hospet

(92) Dam – Trevor Turpin , Reaktion Books Ltd., 33 Great Sutton Street , London EC1V , ODX UK , 2008

(93) Hoover Dam 75th Anniversary History Symposium: Proceedings of the Hoover Dam,
edited by Richard L. Wiltshire, David R. Gilbert, Jerry R. Rogers , American Society Of Civil Engineers , 2010

(94) Note Submitted T0 Dam Safety Review Team Of Central Water Commission Second Visit (02-05-1998).

(95) The Final Solution –Damming The Mahanadi

(96) A Dam Across Mahanadi : A Dream Project Of Dr. A.N. Khosla – Nirakar Mahalik , Orissa Review , 2005

(97) Bombay Fables- Gyan Prakash

(98) Bombay Back Bay – Sir G. Buchanen Involved , Registrar , Saturday 26 , Febraury 1927

(99) Lovely Scene At Back Bay Enquiry : Sir G. Buchanen Complain At Lengthy Enquiry, Undergoes Severe Cross Examination , The Singapore Free Press & Mercanatile Advertiser, 1884-1942 , 11 November 1926 ,

(100) The Growth Of Austarlia : Port Facilities , Sir G. Buchanen Report , The Singapore Free Press & Mercanatile Advertiser, 1884-1942 , 8 Febraury 1927

(101) Sir Geprge Buchanen Questioned , Engineer Job , Cairns Port (Qld 1909-1954) 24, Febraury 1926

(102) Reclamation Scheme Bombay 28 Febraury 1927 , Vol. 203 , 3-4 Common Sittings

(103) Progress Of Scientific Education In India During The Twenty Five Years-1936

(104) Sir M.Visvesvaraya – A.P Srinivasa Murthy , IBH Prakashana , 5th Main Road , Gandhinagara, Bangalore-56009, 1984

(105) Irrigation & Water Supply – John Scot , Grossby Lockwood & Co., 7, Stationers Hall Court , Ludgate Hall , London 1883

(106) Structural Investigation Of Sukkur Barrage Arches – Ch. Mazhar Ali- Paper No. 390, Year 1968

(107) The Lloyd Barrage At Sukkur On The Indus – Jan 22, 1932 , The Engineer

(108) Sindh Water Sector Improvement Phase-1 Project , Secvtion-5 , Terms & References

(109) Minutes Of The Discussion Between The Nile Project Commission And The committee Of Egyptian Engineers – At The Public Meeting Held On 22nd June 1920 , Muniara Cairo

(110) Selections From The Records From The Govt. Of India –Public Works Department , No. CCXV , Public Works Department Serial No.2 , papers Connected With The Periyar Irrigation Project In Madras

(111) On The Design Of Masonry Dams – F.Kreuter (6 Cuts) , Discussion On Impounding Reservoirs (8 Cuts) , Correspondence on Ditto (8 Cuts) , Minutes Of The Proceedings Of The Institution Of Civil Engineers With Other Selcted Absract Papers , Vol. CXV , Edited By – James Forest , 25, Great George Street , Westminster S.W, London , 1894

(112) Report Of The Irrighation 1901-1903 , Appendix , Office Of The Superindenet Of The Government Priniting , Calcutta, India- 1903

(113) Report On The Ganges Canal Works From The Commencement Until The Opening In 1854 Volume 1 , 2 & 3 – Col. Sir Proby T. Cautley , Smith Elder & C0., 65, Corn Hill , London -1860

(114) Dimensions Od Socio-Political Changes In Mysore 1918-1940 , S.Chandrashekhar , Ashih Publishing House , 8/81, Punjabi Bagh , New Delhi 110026, 1985

(115) ಮೋಕ್ಷಗುಂಡಂ ವಿಶ್ವೇಶ್ವರಯ್ಯ : ಜೀವನ-ಸಾಧನೆ , ಒಬ್ಬ ಕರ್ಮ ಯೋಗಿಯ ಕಥೆ ವಿಎಸ್. ನಾರಾಯಣ ರಾವ್ , ಅಂಕಿತ ಪುಸ್ತಕ , ೫೩ , ಶ್ಯಾಮಸಿಂಗ್ ಕಾಂಪ್ಲೆಕ್ಸ್ , ಗಾಂಧಿ ಬಜಾರ್ ಮುಖ್ಯ ರಸ್ತೆ , ಬಸವನಗುಡಿ-ಬೆಂಗಳೂರು-560004 ,, ೨೦೦೮

(116) ಶ್ರೀ ವಿಶ್ವೇಶ್ವರಯ್ಯ ದರ್ಶನ - ಶ್ರೀನಿವಾಸ ದೇಸಾಯಿ , ಸಾಹಿತ್ಯ ಪ್ರಕಾಶನ , ಕೊಪ್ಪೀಕರ್ ಬೀದಿ , ಹುಬ್ಬಳ್ಳಿ , 580020 , 2014

(117) ಕುಲದೀಪಕರು-ಎಸ್. ಕೃಷ್ಣ ಶರ್ಮ , ಲಲಿತ ಸಾಹಿತ್ಯ ಮಾಲೆ , ಧಾರವಾಡ ,1942

(118) ಭಾಗ್ಯಶಿಲ್ಪಿ - ಪರಮೇಶ್ವರ ಭಟ್ಟ , ಸಾರ್ವಜನಿಕ ಶಿಕ್ಷಣ ಇಲಾಖೆ , ಕರ್ನಾಟಕ , 1968

(119) ಯಂತ್ರರ್ಷಿ - 'ರಘುಸುತ' , ಸರ್.ಎಂ.ವಿ ಜೀವನದ ಆತ್ಮೀಯ ಕಥೆಗಳು , ಪುಲಿಕೇಶಿ ಪ್ರಕಾಶನ , 1969

(120) ಭಾರತ ರತ್ನ ಸರ್.ಎಂ. ವಿಶ್ವೇಶ್ವರಯ್ಯನವರ ಪೂರ್ವಜರು-ಡಾ. ಟಿ.ವಿ. ವೆಂಕಟಾಚಲ ಶಾಸ್ತ್ರಿ , ಸಪ್ನ ಬುಕ್ ಹೌಸ್ ಪ್ರೈವೇಟ್ ಲಿ., 11, 3 ನೇ ಮುಖ್ಯ ರಸ್ತೆ , ಗಾಂಧಿನಗರ, ಬೆಂಗಳೂರು, 2011

(121) Agreement Of June 1944 Between Madras & Hyderabad

(122) Mysore State Gazeteer – Mandya District , Director Of Printing , Stationary & Publication, Govt. Press , Bangalore-1967

(123) Modernisation & Optimisation Of Existing Dams & Reservoirs-27th Annual USSD Conference, Philadelphia , Pensylvania , March 5-9, 2007

(124) A Review Of The Classical Method Of Design Of Medium Height Gravity Dams & Aspects Of Base Strengthening With Uplift-Chris Water Meyer , Vol. 48 , No.3 2006 , Journal Of The South African Institute Of Civil Engineering.

(125) Irrigation- College Of Engineering Manual – Col. W.M Ellis , C.I.E , Ptd., By Superintendent , Govt. Press , Madras-1926

(126) Rules Defining The Limits Within Which No Irrigation Works Are To Be Constructed By The Mysore State Without Previous Reference To The Madras Govt.-1892

(127) Award Of Justice H.D.Griffin Arbitrator 1914 , Arbitrators Findings On Terms Of Referrence 1 & 2 (a)

(128) Final Agreement Between The Mysore And The Madras Govt. In Regard To The Construction Of A Dam & A Reservoir At Krishanaraja Sagara-1924

(129) ಭಾರತ ರತ್ನ ಸರ್.ಎಂ.ವಿಶ್ವೇಶ್ವರಯ್ಯ : ಜೀವನ-ಸಾಧನೆ - ತಿ.ತಾ ಶರ್ಮ ಮೂರನೇ ಮುದ್ರಣ , ಅಂಕಿತ ಪುಸ್ತಕ , ಬಸವನಗುಡಿ, ಬೆಂಗಳೂರು-560004 , 2011

DETAILS OF LARGE DAMS OF THE WORLD - UPTO 1930 (MASONRY/CONCRETE GRAVITY)

MWL =Maximum Water Level , FRL=Full Reservoir Level , HD=Height of Dam , HDF=Height of Dam from Foundation , SH=Dam above Weir , TW=Top Width , BW=Bottom Width , L=Length at Top

, A= Sectional Area , A-MWL= Submergence Area at MWL , A-FRL=Submergence Area at FRL ,,V-Tot= Total Storage Capacity at MWL , V= Storage Capacity at FRL , SUS=Stress on U/S , SDS=Stress on D/S , G=Specific Gravity of Masonry , VD=Volume of Dam

(*) Indian Dams

			CONSTRUCTION		WATER LEVEL (FEET/M)		DAM MEASUREMENTS (M/SQ.M)							SUBMERGENCE (SQ.KM)\		CAPACITY (TMC)		PROJECT AREA (HECTARES)		ಒತ್ತಾಯ (Mpa)		ಅಣೆಕಟ್ಟೆಯ ವಿವರ(ಟನ್/ಚ.ಮೀ)		COST (LAKHS)		RATIO PARAMETERS		
NO.	DAM	RIVER/STREAM	START	END	MWL	FRL	HD	HDF	SH	TW	BW	L	A	A-MWL	A-FRL	V-Tot	V	ACHCUT	IRRIGATION	SUS	SDS	G	VD	ESTIMATE	ACTUAL	BW/HD	VD/(L*HDF)	VD/A
1	Elche-Spain		1570	1590			21.05	23.2	9		12	70.15	797.58													0.57		
2	Almanza-Spain	Almanza	1579	1584			20.69	26.24	3		10.29	89.06	130.17							1.4	1.4	2.42				0.50		
3	Tibi (Alicante) -Spain	Monnegre	1579	1594			38.78	41	20.01		33.72	70.15	3610.89							1.12	1.12					0.87		
4	Puentes-Spain	Rio Guadalentin	1785	1791				50				282	4986.45							0.793	0.793							
5	Val do Inferno-Spain	Rio Guadalentin	1785	1791				35.5					1085.42															
6	El Gasco-Spain (*)		1788	1791				53	4		72	82.35																
7	GrosBois - France	Burgundy	1830	1838			22.3	28.3	6.5		14	550	232.84													0.63		
8	Shazilli-France			1840				22.5	4.08		16.62	536																
9	Zola-France	Ifernet		1843				36.5	5.8		12.75	63.5	339.08							0.793	0.793	2.2						
10	Nizar-Spain		1843	1850				30.93			43.89					24.86												
11	Lozoya-Spain	Lozoya		1852				32			39	72.5																
12	Furens-France	Loire tributary	1859	1866			52	56	3			100	996.49			1.92				0.65	0.65							
13	Turne-France		1865	1868				34.35	4		27.2		1328.28							1.44	1.44	2.35						
14	Habra-Algeria	Habrra	1865	1873				33.6	5.5		26.94	450	519.46															
15	Cagliari-Italy	Cagliari		1866				21.5	5		16	105	226.1															
16	Ban-France		1867	1870				46.3					630.71			2.12				0.8	0.8							
17	Gileppe-Belgium	Gileppe		1868				47	15		65.82	235																
18	Lelath-Algiria			1869				21	4		12.3	99								0.614	0.614							
19	BoydS Corner-USA	Croton		1870				23.79	2.6		17.39	204	189.68															
20	Villar-Spain		1870	1878				51.85				167	1978.72			19.98												
21(*)	**Khadakawasla-Maharashtra**	**Mutha**	**1870**	**1879**	**1991**	**1991**	**31.27**	**39.65**	**2.75**	**3.40**	**22.88**	**1047.00**	**523.64**	**15.36**	**15.36**	**3.10**			**5033**	**-0.16**	**1.08**	**2.42**		**3005825**	**3900000**	**0.58**	**0.00**	**0.20**
22	Pas-Du-Riot	Furan	1872	1878				34.5																				
23	Geodonia-Algeria		1873	1875			17	25.5	4		16					0.6				0.943	0.943							
24	Bouzy-France		1878	1881				22					182.42			8.5												
25(*)	Bhatghar - Maharashtra	Elavandi	1878	1892				38.74	2.44	3.66	22.57	1240.00								0.63	0.63					0.58		
26(*)	Muchukhandi-Karnataka		1879	1881	1816	1810	18.30	19.22	1.83	1.83	13.27	159.00		4.89	4.10	0.63	0.58	2167					18318	168420	158707	0.69	6.14	0.13
27	Hijar-Spain			1880				43	5		44.8	72	786.44							0.5	0.5							
28(*)	Jabalpur-Madhyapradesh	Narmada	1881	1883	1458	1454	21.05							1.00	0.95	0.24	0.23			0.45		2	34158		293308			0.24
29(*)	Paricha-Uttar Pradesh	Betwa	1881	1885	639	633	16.17	16.67	1.68	4.65	19.52	1176.00		8.96		3.22	2.95	404520	72000	0.42		2.24		4483776	4371251	1.17		0.36
30	Goandnte-Alexandria			1882				37	7		30.35		526.24															
31	Vyrnwy -U.K			1882				41.48				412																
32	Gran Cgefars-Algiers		1882	1884				30	4		22	155				19.2												
33	Ponta-France			1883			20	26					256.88															
34	Hamiz -Algiria	Hamiz	1885	1885			35.02	35.02	5		27.83	162.26	526.64															
35	Kotate-France			1885				34.5								2.4												
36	Vinzianne-France			1885				24.42												0.7	0.7							
37	Sweet Water-USA		1886	1888				27.45	3.6		14	115.9	218.33															
38	San Maeto-USA		1887	1888				51.85	7.625		53.68		1549.8															
39(*)	Periyar-Kerala	Periyar	1887	1897	2864	2861	48.19	53.68	1.83	3.66	44.07	379.00	1163.51	32.00	28.67	15.67	9.82		78000	0.89		2.25	140517	3392000		0.82	7.28	0.49
40	Taitam-China		1888	1888			28.98		7.16		19.17		370.1															
41	Beetaloo -Australia		1888	1890				33.86	4.27		33.55	177																
42	Tasha-France		1888	1892				49.23																				
43	Remscheid-Germany		1889	1892				25.05	4		15																	
44	ಮೌಷೆ-ಫ್ರಾನ್ಸ್ Moushe-France		1890	1890			30.91	28.98	3.5			410.53																
45	LaGrange-USA			1890				38.125	7.32		27.45																	

			CONSTRUCTION		WATER LEVEL (FEET/M)		DAM MEASUREMENTS (M/SQ.M)							SUBMERGENCE (SQ.KM)		CAPACITY (TMC)		PROJECT AREA (HECTARES)		ಒತ್ತಾಯ (Mpa)		ಆಣೆಕಟ್ಟೆಯ ವಿವರ(ಟನ್/ಚ.ಮೀ)		COST (LAKHS)		RATIO PARAMETERS		
NO.	DAM	RIVER/STREAM	START	END	MWL	FRL	HD	HDF	SH	TW	BW	L	A	A-MWL	A-FRL	V-Tot	V	ACHCUT	IRRIGATION	SUS	SDS	G	VD	ESTIMATE	ACTUAL	BW/HD	VD/(L*HDF)	VD/A
46	Einsiedel-Germany		1890	1894			19.975	28.06			19.98	180																
47	Titicus-USA		1890	1895			33.245	41.175					484.57															
48	Hemmet-USA	San Jesinto		1891				41.32			30.5																	
49(*)	Bhatodi-Gujarat	Mehekari	1891	1892																								
50	Sodom -USA		1891	1893			23.79	29.89	3.66		16.16																	
51	Bates City Water Co.,-USA			1892				36.6	3.05		24.4																	
52	Quaker Bridge-USA		1892	1900			64.05	82.35					2641.92															
53	New Croton-USA		1892	1900			45.75	88.76	5.5		61																	
54(*)	Tansa-Maharashtra	Tansa	1892	1922	342	342	38.13	40.57	1.36	3.74	30.44	2221.00	557.42		18.89	6.52	5.65			0.92		2.4	365785	15730000		0.75	4.19	
55	ವಿಗ್ವ್ಯಾಂ-ಅಸಂಸಂ Wigvyam-USA		1893	1896				27.45				185																
56	Chessman-USA	South Platte		1905			67.4			5.5		224		0.355		3.45												
57(*)	Kodayar-Kerala	Kodeyar	1895	1906	302	296	30.20	46.36	3.05	4.44	32.03			14.98	14.00	4.25	3.50	22270		0.8		2.4	122333	2499971	2607419	0.69		0.28
58(*)	Vanivilasa ssagara-Karnataka	Hagari	1898	1907	2186	2180	43.31	49.82	3.66	4.58	45.75	405.65	842.63		86.58	30.00		10000	4800	0.88		2.4	215250	1830472	1850000	0.92	11.40	
59(*)	Chankapura-Maharashtra	Godavari	1903	1911	167	159	30.80	42.70	2.75	3.54	27.76	460.00	686.06	5.97	4.12	1.54	1.46					2.46		1769569	1345349	0.65	0.00	0.26
60(*)	Theodore Roosevelt-USA	Salt River	1903	1911				85.4		6.6	60	369			81.98	60.18	126.53						272566			0.70		
61(*)	Dukhavan-Uttara Pradesh	Betwa	1904	1909	898	890	14.00	15.25		5.64	15.25	1173.00			19.20		1.58					2.24				1.00	0.00	
62(*)	Path Finder-USA	North Platte	1905	1909	1786.7	1782	58.56	65.27	6.4	3.2	29.4	132				44.19			134000				50200			0.45		
63(*)	Lachura-Uttara Pradesh	Dasun	1906	1910	598	590	13.85	17.39		5.65	16.62	543.00		8.86			1.27					2.24			702288	0.96	0.00	0.00
64(*)	Darna-maharashtra	Godavari	1907	1912	1875	1875	25.62	28.06	3.05	4.58	18.91	1635.00		33.28	33.28	8.82	7.76	87716	24177			2.56	185896	2935631	3427465	0.67	4.24	0.27
65(*)	Pahari-Uttara Pradesh	Dhasan	1907	1913	643	635	13.90	16.47		5.64	15.40	580.00		21.58			2.80					2.24			864578	0.94	0.00	0.00
66(*)	Rampura-Madhya Pradesha	Nagari Nala	1908	1931	212	205	17.08	19.83		2.44	15.25			7.78		1.20						2.24	34355	717861	616641	0.77		0.15
67(*)	Ganagao-Uttara Pradesh	Ken	1909	1915	741	733	13.12	16.17		5.65	14.03	802.00		20.79		3.52	2.10	312400	95041			2.24	77350	1974148	1795536	0.87	6.59	0.17
68(*)	Tigra-Madhya Pradesh	Sanka	1909	1917	745	740	24.40	25.31	2.44	3.05	18.30	1342.00			19.20		4.38			0.6		2.24	180079	5675481	5305978	0.72	5.40	
69(*)	Radha Nagari-Maharashtra	Bhogavati	1909	1951	1939	1939	38.43	42.70	2.44	5.61	30.58	1144.00	712.14	17.92	17.92	8.27	5.97	5600	2800	1.73	0.85	2.25	365785		17000000	0.72	7.88	0.46
70(*)	Lonavala-Maharashtra	Indrayani	1910	1916	2054	2052	15.86	10.52	1.38	1.07	6.71				3.84	0.11						2.28	43950			0.64		
71(*)	Wilson-Gujarath	Pravara	1910	1926	2447	2443	82.35	82.35	1.30	6.40	71.31	508.00	2576.80	20.48			8.67			1.8		2.4	337648	3799291	8414148	0.87	8.07	0.00
72(*)	Valvahanan-Maharashtra	Indrayani	1911	1916	2086	2084	21.66	26.38	1.71	1.22	16.35	1358.00			6.15		2.56					2.28			8517111	0.62	0.00	
73(*)	Krishnaraja Sagara-Karnakatak	Kaveri	1911	1932	2468	2468	40.87	44.53	6.10	3.50	33.86	2440.00	753.55	127.80	127.80	48.78	44.00	48000	36800	0.98		2.33	844120	25000000	25000000	0.76	8.10	0.38
74(*)	Osman Sagar-Telangana	Musi	1912	1920	1810	1784	34.16	36.60		5.50	27.76	1922.00	509.96	41.53	22.19	3.94				0.6		2.25	214608	5840000	5400000	0.76	3.16	0.09
75(*)	Shiravta-Maharashtra	Indrayani	1912	1920	2157	2155	25.32	38.43	2.14	3.66	25.62	2318.00			12.93		6.57					2.34		8256145		0.67	0.00	
76(*)	Ghaghar-Uttar Pradesh	Ghagar	1913	1917	745	743	20.44	20.82	1.83	2.44	13.12	323.00		31.48	30.38	5.39	5.62	80900	28000			2.42	56640	3977863	4273314	0.63	8.50	0.17
77(*)	Llyod-Maharashtra	Elavandi	1913	1928	2045	2045	51.24	59.17	1.37	5.80	37.82	1627.00	872.71	35.84	35.84	2.39	2.39	112733	68431	1.59			764110	17595157	17200000	0.64	8.51	0.07
78(*)	Bornia-upper barrage-Madhya Pradesh	Narmada	1914	1923	554	550	22.57	21.05	2.60	1.83	30.50	318.00		0.28	0.28	0.06	0.05			0.4		2	72453			1.45	10.45	0.21
79(*)	Aleru (pancharam)-Andhrapradesh	Godavari	1916	1922	1469	1464	14.95	30.20	1.53	4.58	19.75	641.00		19.20	16.64		2.40			1.03		2.25	80112	3140000	3212493	0.65	5.54	0.00
80(*)	Tokarawadi-Maharashtra		1916	1922	2195	2190	57.90	59.48	1.53	4.58	45.14	572.00	1251.52	32.05	29.72		12.85			1.13		2.56	2133600	9779000		0.76	63.56	0.00
81(*)	Sir Pirajirao Talav -Maharashtra		1919	1923		1872	11.28	21.96	1.22	2.44	14.26	229.00			0.49		0.10					2.4				0.65	0.00	
82(*)	Himayat Sagara-Telangana	Easi	1919	1926	1780	1762	29.89	33.86		2.44	26.30	2780.00	500.63	37.63	19.46	3.80						2.25				0.78	0.00	0.10
83(*)	Kokoto-Madhya Pradesh	Parvati	1919	1933	1134	1124	32.23	32.63	3.20	3.05	29.36	1048.00			10.78		2.50			0.64		2.24	168824	4161000	3510773	0.90	4.97	
85(*)	Chandia-Madhya Pradesh	Chandia	1921	1927	1325	1319	25.31	25.31	2.75	1.83	13.27	330.00		1.12	0.93	0.20	0.20	1378	625	0.82		2.24	19414	418712	390341	0.52	2.32	0.18
86(*)	Mulshi-Maharashtra	Nila-Mula	1921	1929	1989	1983	44.53	50.63	4.12	5.65	33.10	1557.00	710.00	39.88		18.46				1.-02		2.38	627825	17300000	24964450	0.65	8.47	
87(*)	Wyra-Telangana	Wyra	1922	1933	320.2	314.2	18.60	26.84	3.36	0.60	13.79	1769.00			18.10	2.45	2.04	12400	7000			2.25	115082	2490000	3590266	0.51	2.86	
88(*)	Nizam Sagar-Telangana	Manjra	1923	1931	1405	1400	35.22	48.03	3.50	4.58	36.00	3157.00	763.03	144.67	122.37	29.71	25.60	214615	110000	1.16		2.25	862408	15690000	21848000	0.75		
89(*)	Oda-Madhya Pradesh	Sip	1927	1934	1147	1142	19.22	21.35	1.83	2.44	15.40				9.19		1.55			0.28	0.1	2.24		2768800	2364173	0.72		
90(*)	Mettur-Tamilnadu	Kaveri	1927	1934	796	790	53.68	70.46	3.05	6.25	65.32	1617.00	1954.58		152.00	95.66	93.50	197080	120400	1.66		2.4	1536298	50900000	68000000	0.93	15.31	